THE

GEOLOGICAL MAGAZINE

VOLUME LXII.

No. IV.—APRIL, 1925.

ORIGINAL ARTICLES.

On the Fossil Flora of the Bristol and Somerset Coalfield.

By Robert Crookall.

(PLATES VI–IX.)

Part I.

I. Object of the Work.

THIS investigation was undertaken with a view to increasing the known flora of the Bristol and Somerset Coalfield, and applying the results to stratigraphical purposes. The stratigraphical results aimed at were :—

(1) To subdivide the strata on palaeobotanical criteria, correlating the Coal Measures of this area with those of other British Coalfields.

(2) To elucidate the geology of the Central or Pensford Area of the coalfield.

(3) To determine, if possible, the geological age of the upper beds of the "Millstone Grit" of this district.

II. Description of Area.

The Bristol and Somerset Coalfield extends from Cromhall, Gloucestershire, in the north, to Frome, Somersetshire, in the south (a distance of about 26 miles); east to west it stretches from Bath to Nailsea (about 24 miles).

Although its total area amounts to rather more than 150 square miles, about one-fifth only of this is exposed at the surface, the remainder being covered by newer formations.

There are, in all, about 140 coal-seams, with a total thickness of 107 feet, but many of these are too thin to be worked.

III. Previous Work on the Flora.

The chief work on the flora of this coalfield was published in 1887 by the late Dr. Kidston,[1] who recorded 98 species from the Radstock Series, 33 from the Farrington Series of the Southern Area, and 15 from the Farrington Series of the Northern Area, 6 species from the Pennant Rock, 16 from the New Rock Series, and 8 from the Vobster Series.

[1] R. Kidston (1887), *Proc. Roy. Soc. Edinb.*, xxxiii, pt. ii, pp. 335–417.

Nothing further was published on the subject until D. J. Lillie's[1] paper in 1910, when 13 species were added to the known flora of the Farrington Series of the Northern Area.

In "Summary of Progress" for 1913 Kidston[2] gave a list of plants from a boring at Hemington, Somerset which, however, contained no species hitherto unrecorded from the coalfield.

In 1914 the late Dr. Arber[3] mentioned 4 species of seeds from this coalfield which had not been previously recorded, 3 from the Radstock and 1 from the Farrington Series.

Kidston and Jongmans,[4] in 1917, mentioned 3 additional species of *Calamites* from the Radstock Series and 1 from the New Rock Series.

Arber,[5] in 1922, recorded 2 additional species of *Lepidostrobus* from the Radstock Series and 2 from the Farrington Series, and, in the following year, Kidston[6] described and figured a new species of *Sphenopteris* from the Radstock Series.

The complete flora of the coalfield published to date as is follows:

Radstock Series	107	species.
Farrington Series—		
Northern Area	31	,,
Southern Area	33	,,
Pennant Rock	6	,,
New Rock Series	17	,,
Vobster Series	8	,,

Note.—Full references are given in the List of Works cited on p. 178.

IV. The Geology of the Coalfield.

The most recent views on the geology of the coalfield were recapitulated in 1900 by M'Murtrie.[7]

The coalfield is divided into two districts by the Kingswood anticline, which occurs between Bristol and Warmley. The southern district is sub-divided by the Farmborough Fault, which crosses the coalfield from east to west a little to the north of Camerton and Timsbury. For the purpose of this paper, therefore, the Bristol and Somerset Coalfield will be regarded as consisting of three tracts, namely:—

The Northern or Gloucestershire Area,
The Central or Pensford Area, and
The Southern or Radstock Area.

The Coal Measures of the Bristol and Somerset Coalfield divide

[1] D. G. Lillie (1910), Geol. Mag., pp. 58–67.
[2] R. Kidston (1913–14), *Sum. Prog. Geol. Surv.*, 1913, p. 101.
[3] E. A. N. Arber (1914[2]), *Ann. of Bot.*, xxviii, pp. 96, 98, 101.
[4] R. Kidston and W. J. Jongmans (1917), *Monogr. of Calamites of W. Europe*, pp. 35, 95, 104, 178.
[5] E. A. N. Arber (1922), *Journ. Linn. Soc.*, xlvi, pp. 178, 180, 186.
[6] R. Kidston (1923), *Mems. of Geol. Surv. of Gt. Britain*, ii, pt. ii, p. 150.
[7] J. M'Murtrie (1900), Annual Meeting, Inst. of Mining Eng., 1900.

naturally into an " Upper " and a " Lower " Division, these being separated by 2,500 to 3,000 feet of Pennant Rock.

The " Upper Division " consists of two groups, the Radstock Series (of 8 coal-seams) and the Farrington Series (of usually 6 seams). Between the Radstock and Farrington Series are 540 to 720 feet of strata near the middle of which are beds of red shale from 130 to 250 feet in thickness.

The " Lower Division ", including the strata lying between the Pennant Rock and the " Millstone Grit ", underlies the entire coalfield, and contains about 37 coal-seams, of which 26 are productive. This Division includes the New Rock and Vobster Series.

The general section of the coalfield in the Southern Area is as follows :—

Radstock Series.	" Upper Division " [1]
Red Shales.	of Coal Measures
Farrington Series.	(2,200 feet).
Pennant Rock.	(2,500 to 3,000 feet).
New Rock Series.	" Lower Division " [1]
	of Coal Measures.
Vobster Series.	(2,800 feet).
" Millstone Grit."	(900–1,000 feet).
Carboniferous Limestone.	

The geology of the Southern and Northern Areas of the Bristol and Somerset Coalfield is fairly well known, but that of the Central Area has not hitherto been satisfactorily explained, owing to the Farmborough Fault. M'Murtrie [2] has pointed out that " the prevailing idea locally is that the Farmborough Fault . . . is an upthrow north of 600 feet, throwing out the Radstock Series in the district immediately to the north of the fault . . . Professor Prestwich, however, is of opinion that the local view is inaccurate, and that more probably the Farmborough Fault is a downthrow north, bringing in certain coal-strata overlying the Radstock Group ". In 1900, the same author (M'Murtrie, op. cit., pp. 28–9) said that the Farmborough Fault " has long been a puzzle to mining engineers and geologists, all attempts to find the Radstock Seams north of it having failed ".

For economic reasons it is very improbable that further pits will be opened in the Central Area, so that the problem as to the position of the Coal Measures worked there might well remain unsolved were it not possible to employ palaeobotanical data, as will here be attempted.

V. Notes on Collieries.

The following is a complete list of the collieries now operating in the coalfield :—

[1] These are local terms only.

[2] M'Murtrie (1875), *Somerset Arch. and Nat. Hist. Soc.*, 1875, p. 44.

Series worked.	*Collieries.*
NORTHERN AREA.	
Farrington Series . . .	Parkfield Colliery, Pucklechurch.
	Coalpit Heath Colliery.
New Rock Series . . .	Deep and Speedwell Pits, Kingswood, Bristol.
	South Liberty Colliery, Bedminster, Bristol.
Vobster Series . . .	Hanham Colliery.[1] (Mr. Sharp, the manager, believes that the Vobster Series are worked here, as surmised by Lillie (1910, p. 59)).
CENTRAL AREA.	
Unknown	Broad Oak Colliery, Pensford.
	Bromley Colliery.[2]
SOUTHERN AREA.	
Radstock Series . . .	Priston, Clandown, Camerton, Dunkerton, and Wellsway Pits.
Radstock and Farrington Series	Braysdown and Kilmersdon Pits.
Farrington Series . . .	Old Mills, Middle, Lower Writhlington, Foxcote, and Ludlow's Pit. Also probably Norton Hill,[3] Marsh Lane,[4] and Bishop Sutton New Pit.
New Rock Series . . .	Mells, New Rock, and Newbury.
Vobster Series . . .	(Probably at) Holcombe.

VI. MATERIAL.

The present work is concerned with impressions, moulds, and casts only, but Lillie (op. cit., p. 60) mentioned that a limited amount of petrified material was obtained.

The following fossils are in the collection of the Bristol Museum, and my thanks are due to the Director, Dr. H. Bolton, for permission to examine them.

Sigillaria major L. & H., from Downend (Pennant Rock).

? *Dicksoniites pluckenetii* Schloth. sp., from Golden Valley (New Rock Series).

Cyclopteris orbicularis Brongt., from Golden Valley (New Rock Series).

Neuropteris ? *heterophylla* Brongt., from Norton Hill Pit (? Farrington Series).

Caulopteris cistii Brongt., from Radstock.

Sigillaria major L. & H., from Camerton (Radstock Series).

[1] The two quarries to the south and south-east of Hanham Pit are in the Pennant Rock, which, both here and at Temple Cloud, contains fragments of preserved wood. *Neuropteris* sp. and *Sigillaria* sp. were collected in the Hanham Quarries.

[2] Two coal-seams are worked at both Broad Oak and Bromley Collieries.

[3] Mr. Bennett, the manager of Norton Hill Colliery, thinks they are working seams which "do not exist anywhere else in the second (Farrington) Series, thrown in and out by faults".

[4] The manager of the drive at Marsh Lane, Farrington Gurney, says they are working seams below the Farrington Series proper.

In the following lists [1] the frequency with which a species occurs at a certain locality is expressed by numbers, thus :—

8–10 = very common. 6–7 = fairly common.
3–4 = fairly rare. 1–2 = very rare.

In cases where the horizon is known, this is stated before the number indicating the frequency.

TERIDOSPERMAE AND FILICALES.	*Radstock Colliery.*	*Norton Hill Pit.*	*Bishop Sutton New Pit.*	*Old Mills Pit.*	*Marsh Lane Pit.*
copteris polymorpha Brongt. .	(5)	—	—	—	—
„ *arborescens* Schloth. sp. .	(4)	(5)	—	—	—
„ *miltoni* Artis sp. . .	(6)	—	—	—	21 in.* and Inferior Seams (3)
„ „ forma *abbreviata* Bgt. pro. sp.	(7)	(5)	Great Seam (3)	—	21 in.* Seam (2)
„ *unita* Brongt. . .	(7)	(5)	Great Seam (3)	—	21 in.* Seam (2)
„ *cyathea* Schloth. sp. .	—	(2)	—	—	—
„ *crenulata* Brongt. . .	—	(2)	Little Seam (1)	—	—
„ sp.	—	—	Little Seam (1)	—	—
ctylotheca plumosa Artis sp. .	—	(3)	—	(3) *	—
lethopteris aquilina Schloth. sp. .	(1)	—	(3)	—	—
„ *serlii* Brongt. sp. .	(10)	(10)	Little Seam (5)	(8) *	21 in.* Seam (8)
„ *davreuxi* Brongt. sp. .	—	—	(3)	—	—
„ *lonchitica* Schloth. sp. .	—	—	(2)	—	—
cksoniites pluckenetii Schloth. sp.	—	—	—	—	21 in.* Seam (3)
lontopteris lindleyana Sternb. .	—	—	(3)	—	—
ariopteris muricata Schloth. sp. .	(3)	—	Little Seam (2)	(3) *	21 in.* Seam (1)
uropteris flexuosa Sternb. . .	(10)	(8)	Great and Little Seams (7)	(2) *	Inferior * Seam (4)
„ *scheuchzeri* Hoffm. .	(10)	—	Great and Little Seams (8)	(7) *	21 in.* Seam (4)
„ *rarinervis* Bunb. .	—	(6)	(6)	—	Inferior* Seam (5)
„ *ovata* Hoffm. . .	—	(6)	Little Seam (4)	—	—
„ *macrophylla* Brongt. .	—	—	Little Seam (5)	(2) *	—
„ *fimbriata* Lesqx. . .	—	—	—	(1) *	—
hlebia sp.	—	—	(1)	—	—
clopteris sp.	—	(4)	(6)	—	—
henopteris sp.	(1)	(1)	—	—	—
„ *macilenta* L. & H. .	? (1)	—	Little Seam (2)	(1) *	21 in.* Seam (3)
„ *ovatifolia* Lillie . .	—	? (1)	—	—	—

[1] All the plants listed, with the exception of those marked *, were examined, and their identifications checked, by the late Dr. Kidston, for whose kindly assistance in this matter I am extremely grateful.

Pteridospermae and Filicales.	Radstock Colliery.	Norton Hill Pit.	Bishop Sutton New Pit.	Old Mills Pit.	Mari Lane Pi
Sphenopteris neuropteroides Boulay sp.	—	—	(4)	(4) *	–
Diplotmema sp.	—	(1)	—	—	–
Rhacophyllum filiciforme Gut. sp.	(2)	—	—	—	–
Radstockia sp.	—	? (1)	—	—	–
Dolerophyllum sp.	—	? (1)	(2)	—	–
Crossotheca sp.	—	—	(1)	—	–
Semina incertae sedis.					
Schizospermum noeggerathi Sternb. sp.	(1)	—	—	—	–
Carpolithes sp.	—	—	—	(1) *	–
Lycopodiales.					
Sigillaria tessellata Stein sp.	(3)	(6)	(2)	—	–
,, *m'murtriei* Kidst.	(1)	—	—	—	–
,, *nortonensis* n.sp.	—	(1)	—	—	–
,, *ovata* Sauv.	—	? (1)	—	—	–
,, sp.	—	—	—	(2) *	–
,, *cumulata* Weiss var. *nodosa* L. & H.	—	—	—	—	Inferior Seam (2
Asolanus camptotaenia Wood.	—	—	(1)	—	–
Sigillariostrobus sp.	(1)	—	—	—	–
Sigillariophyllum bicarinatum L. & H. sp.	—	(5) *	Great Seam (5)	(6) *	21 in.* a Inferior Seams (1
Lepidodendron aculeatum Sternb.	(8) *	(8)	(3)	—	–
,, *wortheni* Lesqx.	—	(8)	Great Seam (3)	—	–
,, *lanceolatum* Lesqx.	—	(7)	(4)	—	–
,, sp.	—	(1)	—	(1) *	–
Lepidostrobus minor Goode	(1) *	? (5)	—	(3) *	–
,, *lanceolatus* L. & H. sp.	(1) *	(4)	(2)	(8) *	21 in.* a Inferior Seams (8
,, *triangularis* Zeiller	—	(1)	—	(1) *	Inferior Seam (2
,, sp.	—	—	(2)	—	–
Lepidophyllum sp.	—	—	(4)	—	–
Lycopod megaspores	—	—	—	—	Inferior Seam (1
Lepidophloios laricinus Sternb.	—	(1)	—	—	–
Stigmaria anglica Sternb. sp.	(1)	—	—	—	–
,, *ficoides* Sternb. sp.	(3)	(5)	(4)	(2) *	–
Equisetales.					
Calamites undulatus Sternb.	? (1)	—	—	—	–
,, sp.	—	—	Great and Little Seams (6)	—	–
,, *suckowii* Brongt.	—	—	—	(2) *	–
Annularia stellata Schloth. sp.	(8)	(7)	—	(4) *	–
,, *sphenophylloides* Zenk. sp.	—	(6)	(3)	(3) *	Inferior Seam (3
Asterophyllites equisetiformis (Schl.)	—	—	(2) *	—	–
Pinnularia capillacea L. & H.	(5)	—	(5) *	—	21 in Seam (8) *
,, *columnaris* Artis sp.	—	—	—	—	21 in Seam (2) *

Sphenophyllales.	*Radstock Colliery.*	*Norton Hill Pit.*	*Bishop Sutton New Pit.*	*Old Mills Pit.*	*Marsh Lane Pit.*
Sphenophyllum emarginatum Brongt.	(8)	(8)	(3)	(5)*	21 in * Seam (8)
„ sp. . . .	(1)	—	—	—	—
„ ? *longifolium* Germar	—	—	—	—	21 in.* Seam (1)
Cordaitales.					
Cordaites sp.	(4)	(6)	Great Seam (4)	—	Inferior * Seam (4)
„ cf. *principalis* Germar .	—	—	(2) *	—	—

Pteridospermae and Filicales.	*Parkfield Pit.*	*Coalpit Heath Colliery.*
Pecopteris miltoni Artis sp. . .	Hard and Top Veins (8)	Hard Vein (8)
„ *oreopteridia* Schloth. sp..	Top Vein (2)	(2)
„ *arborescens* Schloth. sp. .	Top Vein (3)	(3)
„ *bucklandii* Brongt. .	? (1)	(1)
„ *polymorpha* Brongt. .	(6)	Hard Vein (5)
„ *unita* Brongt. . .	(3)	(4)
Eupecopteris sp.	—	(1)
Dicksoniites pluckenetii Schloth. sp.	(2)	(2)
Dactylotheca plumosa Artis sp. .	(2)	(3)
Alethopteris davreuxi Brongt. sp. .	(4)	—
„ *serlii* Brongt. sp. .	Top Vein (1)	—
„ *aquilina* Schloth. *non* Brongt.	(2)	(2)
„ *pontica* Zeiller . .	(2)	(1)
„ *grandini* Brongt. sp. .	—	(2)
„ cf. *integra* Gothan sp. .	—	(1)
Sphenopteris alata Brongt. . .	(2)	(2) *
„ *pecopteroides* Kidst. .	(1)	—
„ *neuropteroides* Boulay sp.	(3)	(3)
„ ? *ovatifolia* Lillie .	—	(1)
Renaultia chaerophylloides Brongt. sp.	(1)	(1)
Mariopteris muricata Schl. sp. .	? Top Vein (3)	—
Cyclopteris sp.	(2)	(4)
Neuropteris fimbriata Lesqx. .	(3)	(3)
„ *scheuchzeri* Hoffm. .	(5)	(5)
„ *flexuosa* Sternb. . .	Hard, Top, and Great Veins (6)	—
„ *ovata* Hoffm. . .	(6)	—
„ *rarinervis* Bunb. .	—	(4)
„ *macrophylla* Brongt. .	—	(4)
Aphlebia sp.	(2)	(1)
Radstockia sp.	(1)	—
Caulopteris peltigera Brongt. .	—	(1)
Cf. *Megaphyton* sp. . . .	—	(1)
Lycopodiales.		
Sigillaria major, L. & H. . .	(2)	(2)
„ *deutschiana* Brongt. .	(2)	—
„ *rugosa* Brongt. . .	(3)	(3)
„ *mamillaris* Brongt..	(2)	—
„ *elongata* Brongt. . .	(2)	(2)
„ *tessellata* Stein sp. . .	—	High and Hollybush Veins (2)

	Parkfield Pit.	*Coalpit Heath Colliery.*
LYCOPODIALES.		
Asolanus camptotaenia Wood .	—	(1)
Sigillariophyllum bicarinatum L. & H. sp.	(4)	Hollybush Vein (4)
Lepidodendron lanceolatum Lesqx. .	Hard and Great Veins (4)	(5)
,, *loricatum* Arber (pars)	(3)	(3)
,, *aculeatum* Sternb. .	Hard and Great Veins (5)	(6)
,, cf. *jaraczewskii* Zeiller	—	(1)
,, *rimosum* Sternb. .	—	(2)
,, *worthenii* Lesqx. .	—	(6)
,, ? *obovatum* Sternb. .	Great Vein (1)	(1)
Lepidostrobus brevifolius Lesqx. .	(1)	—
,, *lanceolatus* L. & H. sp.	(2)	(2)
,, *majus* Brongt. .	? (1)	—
,, *minor* Goode . .	Hard and Great Veins (4)	Hard and High Veins (4)
Lycopod megaspores . . .	—	(5)
Lepidophloios laricinus Sternb. .	(2)	(2)
Stigmaria ficoides Sternb. sp. .	(3)	(4)
EQUISETALES.		
Calamites suckowii Brongt. . .	(5)	(5)
Annularia stellata Schloth. sp. .	(4)	Hard and High Veins (3)
,, *radiata* Brongt. . .	—	(2)
Asterophyllites equisetiformis (Schl.)	(3)	(3)
Pinnularia capillacea L. & H. .	(5)	(6)
Macrostachya cf. *infundibuliformis* Brongt.	—	(1)
SPHENOPHYLLALES.		
Sphenophyllum emarginatum Brongt.	Hard and Top Veins (2)	Hard and Hollybush Veins (4)
,, *longifolium* Germar.	—	(1)
,, sp. . . .	—	(1)
CORDAITALES.		
Cordaites sp.	Hollybush Vein (5)	Hollybush and High Veins (3)
? *Cordaicarpus* sp. . . .	—	(1)
FUNGI.		
Excipulites callipteridis Schimp. sp.	(1)	—

	Broad Oak Colliery, Pensford.	*Bromley Colliery near Pensford.*
PTERIDOSPERMAE AND FILICALES.		
Eupecopteris camertonensis Kidst. .	—	No. 4 Seam (1)
Pecopteris oreopteridia Schloth. sp. .	(2)	? No. 5 Seam (1)
,, *polymorpha* Brongt. . .	(3)	—
,, *miltoni* Artis sp. . .	(5)	No. 5 Seam (4)
,, *crenulata* Brongt. . .	(1)	No. 5 Seam (1)
,, *arborescens* Schloth. sp. .	(2)	—
,, *candolliana* Brongt. . .	(1)	(1)
,, *bucklandii* Brongt. . .	(1)	—
,, *unita* Brongt. . . .	—	No. 5 Seam (2)

PTERIDOSPERMAE AND FILICALES.	*Broad Oak Colliery, Pensford.*	*Bromley Colliery near Pensford.*
Dactylotheca plumosa Artis sp. . .	(2)	(1)
Corynepteris sternbergii Ett. sp. .	(1)	—
Sphenopteris neuropteroides Boulay sp.	(4)	No. 5 Seam (6)
,, *macilenta* L. & H.. .	(1)	No. 4 Seam (1)
,, sp.	(1)	—
,, *laurenti* Andrae . .	—	No. 5 Seam (1)
Renaultia chaerophylloides Brongt. sp.	(1)	—
Mariopteris muricata Schloth. sp. .	(3)	No. 5 Seam (3)
,, ,, forma *nervosa* L. & H. pro sp.	(2)	No. 4 Seam (2)
Alethopteris serlii Brongt. sp. . .	(1)	No. 5 Seam (5)
,, cf. *valida* Boulay . .	(1)	—
,, *davreuxi* Brongt. sp. .	(2)	—
,, *aquilina* Schloth. sp. .	—	No. 5 Seam (2)
Neuropteris flexuosa Sternb. . .	(8)	No. 5 Seam (6)
,, *scheuchzeri* Hoffm. . .	(9)	Nos. 4 and 5 Seams (8)
,, *fimbriata* Lesqx. . .	(4)	(3)
,, *ovata* Hoffm. . .	(5)	No. 5 Seam (8)
,, *schlehani* Stur. . .	(1)	—
,, *rarinervis* Bunb. . .	(4)	No. 5 Seam (7)
,, *macrophylla* Brongt. .	(4)	No. 5 Seam (5)
,, *spiropteris* . . .	(1)	—
Cyclopteris orbicularis Brongt. . .	—	No. 5 Seam (2)
,, sp.	(3)	No. 4 Seam (1)
Aphlebia crispa Gut. . . .	(1)	—
,, sp.	—	(1)
Dolerophyllum sp.	(1)	—
Odontopteris lindleyana Sternb. .	(3)	Nos. 4 and 5 Seams (4)
,, *alpina* (Sternb.) Gein. .	(1)	—
,, sp.	—	(1)
Spiropteris sp.	(1)	—
SEMINA INCERTAE SEDIS.		
Trigonocarpus parkinsoni Brongt. .	(2)	No. 4 Seam (2)
Holcospermum mamillatum Lesqx. sp.	(3)	—
Cf. *Carpolithes* sp.	(2)	—
Samaropsis sp.	—	(1)
LYCOPODIALES.		
Sigillaria ovata Sauv. . . .	(2)	—
,, *tessellata* Stein sp. . .	(3)	(3)
,, cf. *germanica* Weiss. . .	(1)	—
,, *cumulata* Weiss, var. *nodosa* L. & H.	(1)	—
,, *mauricii* Grand 'Eury .	(1)	—
,, *transversalis* var. *sparsifolia*, Boul.	(1)	—
,, *kidstoni* n. sp. . . .	(1)	—
Sigillariophyllum bicarinatum L. & H. sp.	(3)	Nos. 4 and 5 Seams (4)
Lepidodendron aculeatum Sternb. .	(4)	No. 4 Seam (5)
,, *wortheni* Lesqx. .	(5)	No. 4 Seam (5)
,, *lanceolatum* Lesqx. .	(4)	(3)
,, *distans* Lesqx. . .	(1)	—
,, *obovatum* Sternb. .	—	(4)
Lepidostrobus brevifolius Lesqx. sp. .	(2)	—
,, *lanceolatus* L. & H. sp.	(2)	(2)

	Broad Oak Colliery, Pensford.	Bromley Colliery near Pensford.
LYCOPODIALES.		
Lepidostrobus minor Goode	(4)	(3)
,, *triangularis* Zeiller	(1)	—
,, sp.	(1)	—
Stigmaria ficoides Sternb. sp.	(4)	(4)
EQUISETALES.		
Calamites carinatus Sternb.	(2)	No. 4 Seam (3)
,, *suckowii* Brongt.	—	(4)
,, sp.	—	(1)
Asterophyllites equisetiformis Schl. sp.	(4)	—
Annularia sphenophylloides Zenk. sp.	(4)	(3)
,, *stellata* Schl. sp.	(5)	(4)
,, *radiata* Brongt.	—	No. 4 Seam (3)
Pinnularia capillacea L. & H.	(5)	Nos. 4 and 5 Seams (4)
Stachannularia tuberculata Sternb. sp.	(1)	—
Calamite cones	—	(1)
SPHENOPHYLLALES.		
Sphenophyllum longifolium Germar	? (1)	No. 5 Seam (1)
,, *emarginatum* Brongt.	(3)	No. 4 and 5 Seams (3)
,, *cuneifolium* forma *saxifragaefolium* Sternb. pro sp.	(1)	—
,, sp.	—	No. 5 Seam (1)
,, sp.	—	No. 5 Seam (1)
CORDIATALES.		
Cordaites sp.	(4)	—
,, *angulosostriatus* (Kidst.) Grand 'Eury.	(1)	—
,, *borassifolius* Sternb. sp.	—	Nos. 4 and 5 Seams (2)
Poacordaites microstachys Gold. sp.	(1)	—
FUNGI.		
Excipulites callipteridis Schimp. sp.	(1)	—

	Deep Pit.	Speedwell Pit.	South Liberty Pit.	Mells Colliery.	Newbury Pit.
PTERIDOSPERMAE AND FILICALES.					
Pecopteris volkmanni Sauv.	(2)	—	—	—	—
Dactylotheca plumosa Artis sp.	(1)	—	—	—	—
Alethopteris lonchitica Schloth. sp.	—	(1)	—	—	—
Desmopteris elongata (Presl.)	(1)	—	—	—	—
Sphenopteris laurenti Andrae	(1)	—	—	—	—
,, *dilatata* L. & H.	(1)	—	—	—	—
,, *tenuissima* Presl.	(1)	—	—	—	—
,, sp.	(1)	—	—	(1)	—
,, *neuropteroides* Boul sp.	—	—	—	—	(1)
Rhodea sp.	(1)	—	—	—	—
Diplotmema furcatum Brongt. sp.	(2)	—	—	—	—
Corynepteris sternbergii Ett. sp.	(1)	—	—	—	—
,, *coralloides* Gut. sp.	—	—	—	—	(1)
Crossotheca sp.	(1)	—	—	—	—
Dolerophyllum sp.	(1)	—	—	—	—
Mariopteris muricata Sch. sp.	(4)	—	—	—	—
,, ,, forma *nervosa* L. & H. pro sp.	—	(1)	—	(2)	(2)

PTERIDOSPERMAE AND FILICALES.	*Deep Pit.*	*Speedwell Pit.*	*South Liberty Pit.*	*Mells Colliery.*	*Newbury Pit.*
Neuropteris cf. *raymondi* Zeiller	(1)	—	—	—	—
„ *pseudogigantea* Potonié	(1)	(1)	(1)	—	—
„ *heterophylla* Brongt.	—	(1)	(1)	? (1)	—
„ sp.	—	(1)	(1)	—	—
„ *scheuchzeri* Hoffm.	—	(1)	(1)	—	(2)
„ *macrophylla* Brongt.	—	—	—	(1)	(1)
„ *rarinervis* Bunb.	—	—	—	(2)	(3)
Dictyopteris munsteri Eich. sp.	—	—	—	—	(1)
Spiropteris sp.	(1)	—	—	—	—
SEMINA INCERTAE SEDIS.					
Trigonocarpus sp.	(1)	—	—	—	—
Megalospermum inflatum Lesqx. sp.	(1)	—	—	—	—
„ sp.	—	—	—	—	(1)
Samaropsis sp.	—	—	—	—	(1)
LYCOPODIALES.					
Sigillaria rugosa Brongt.	—	—	—	(2)	—
„ *mamillaris* Brongt.	(1)	—	—	—	—
„ *scutellata* Brongt.	(1)	—	—	(1)	—
„ *elongata* Brongt.	(1)	—	—	—	—
„ *cordigera* Zeiller	(1)	—	—	—	—
„ *major* L. & H.	(1)	—	—	—	—
„ *tessellata* Stein sp.	—	—	—	(2)	(1)
„ *ovata* Sauv.	—	—	—	—	(1)
„ *saulii* Brongt.	—	—	—	—	(1)
Sigillariophyllum bicarinatum L. & H. sp.	—	(2)	(2)	—	—
Lepidodendron aculeatum Sternb.	(1)	(1)	(1)	—	—
„ *wortheni* Lesqx.	(2)	(1)	—	—	—
„ *ophiurus* Brongt.	(1)	(2)	—	—	—
„ *obovatum* Sternb.	(2)	(1)	(1)	—	—
„ sp.	—	(1)	—	(1)	(1)
„ *lanceolatum* Lesqx.	—	—	—	—	(1)
Lepidophyllum sp.	—	—	(1)	—	—
Lepidostrobus minor Goode	(3)	(2)	—	—	—
„ *morissianum* Lesqx.	(1)	—	—	—	—
„ *incertus* Lesqx.	(1)	—	—	—	—
„ *lanceolatus* L. & H. sp.	(1)	—	—	—	—
„ *triangularis* Zeill.	—	(1)	—	—	—
Lycopod megaspores	(2)	—	—	—	—
Stigmaria ficoides Sternb. sp.	(4)	(3)	(1)	(4)	—
„ *minuta* Göpp.	—	(1)	—	—	—
EQUISETALES.					
Calamites suckowii Brongt.	(3)	—	(?)	—	—
„ *undulatus* Sternb.	(3)	(1)	—	—	—
„ sp.	—	(1)	—	—	(1)
Annularia radiata Brongt.	(3)	—	—	—	(2)
„ *sphenophylloides* Zenk. sp.	(1)	—	—	—	(1)
„ sp.	—	(1)	(1)	—	—
Asterophyllites equisetiformis Sch. sp.	(2)	—	(1)	(2)	—
„ *grandis* Sternb. sp.	(2)	—	—	—	—
Pinnularia capillacea L. & H.	(4)	—	—	—	—
„ *columnaris* Artis sp.	(4)	—	—	—	—

	Deep Pit.	Speedwell Pit.	South Liberty Pit.	Mells Colliery.	Newbury Pit.
SPHENOPHYLLALES.					
Sphenophyllum cuneifolium Sternb.	(3)	(1)	—	(2)	—
,, ,, forma *saxifrageafolium*, Stb. pro sp.	(2)	—	—	—	—
,, *myriophyllum* Crépin	(1)	—	—	—	—
,, *trichomatosum* Stur.	(1)	—	—	—	—
,, *emarginatum* Brongt.	—	—	—	—	(1)
CORDAITALES.					
Cordaites borassifolius Sternb. sp.	—	—	—	(2)	—
,, sp.	—	(2)	—	—	—
,, *principalis* (Germar)	(1)	—	(2)	—	—
Artisia approximata Brongt. sp.	(1)	—	—	—	—
,, *transversa* Art. sp.	(1)	—	—	—	—
Cordaicarpus cordai Gein. sp.	(1)	—	—	—	—
,, *areolatus* (Boulay)	(1)	—	—	—	—

LOCALITY: HANHAM COLLIERY,
about 3½ miles East of Bristol, Gloucestershire.

	Frequency.
PTERIDOSPERMAE AND FILICALES.	
Alethopteris decurrens Artis sp.	1
Mariopteris muricata Schloth. sp.	1
Neuropteris heterophylla Brongt.	1
,, cf. *pseudogigantea* Potonié	1
,, sp.	
Cf. *Dolerophyllum* sp.	1
Spiropteris sp.	1
LYCOPODIALES.	
Sigillaria sp.	
Lepidodendron obovatum Sternb.	1
,, cf. *rimosum* Sternb.	1
,, sp.	
Lepidostrobus sp.	
Lycopod megaspores	2
Stigmaria ficoides Sternb. sp.	3
EQUISETALES.	
Annularia sp.	1
Calamites suckowii Brongt.	2
,, *undulatus* Sternb.	1
Pinnularia capillacea L. & H.	3
CORDAITALES.	
Dory-cordaites palmaeformis Gut.	2
Cordaites sp.	
Artisia transversa Artis sp.	1
SPHENOPHYLLALES.	
Sphenophyllum cuneifolium Sternb. sp.	1
,, sp.	

From the Upper Beds of the "Millstone Grit".[1]	*Quarry near Fanshaw Court, Yate.*	*Wick Rocks.*	*Strontium Quarries, Yate.*
Pteridospermae and Filicales.			
Sphenopteris sp.	(1)	—	(2)
Odontopteris conwayi L. & H. sp.	—	—	(10)
Lycopodiales.			
Lepidophyllum sp.	—	—	(2)
Sigillariophyllum bicarinatum L. & H. sp.	(3)	—	—
Lepidodendron distans Lesqx.	—	—	(1)
Lepidophloios cf. *laricinus* Sternb.	—	—	(1)
Lepidostrobus sp.	—	—	(2)
,, *lanceolatus* L. & H. sp.	—	—	(2)[1]
Stigmaria ficoides Sternb. sp.	—	(1)	—
Equisetales.			
Calamites sp.	(4)	—	—
,, *undulatus* Sternb.	—	—	(1)
Sphenophyllales.			
Sphenophyllum trichomatosum Stur.	—	—	(10)
,, sp.	—	—	(1)

VII. Descriptions of, and Remarks on, Certain Species.

PTERIDOSPERMAE AND FILICALES.

Eupecopteris.

Eupecopteris Camertonensis Kidston MS. (Fide Dr. R. Kidston).

Description.—Pinnae alternate, about 18 mm. long. Pinnules quite oval, alternate, 1·5 mm. long by 1 mm. broad, directed forwards. Veins clearly marked, of equal strength, both median and lateral veins often pursuing a sinuous course. Lateral veins sometimes arched, nearly always simple. Margins of pinnules contiguous or overlapping slightly.

Remarks.—Two fragments of this species, the description of which is not yet published, were collected at Bromley Colliery. A fragment identified by Dr. Kidston as *Eupecopteris* sp. was also collected at Coalpit Heath.

Pecopteris Brongniart, 1822.

1. *Pecopteris* (*Asterotheca*) *cyathea*, Schloth. sp.

Brongt., Hist. (1828), i, p. 307, pl. ci, figs. 1–3.

Remarks.—*Pecopteris arborescens* Schloth. sp. and *P. cyathea* were united by Kidston (1887, p. 366), but he recently expressed the view that the two are distinct species, thus agreeing with Zeiller and Grand 'Eury. In *P. arborescens* the lateral veins are simple, while in *P. cyathea*, though occasionally simple, they usually divide once (rarely more).

[1] I am indebted to Mr. P. B. Roberts, B.Sc., of Bristol, for drawing my attention to the plants occurring in these rocks.

2. *Pecopteris* (*Asterotheca*) *crenulata* Brongniart. (Pl. VII, Fig. 3.)

Brongt., Hist. (1828), i, p. 300, pl. lxxxvii, fig. 1.—Zeiller (1886–8), Valenc., p. 192, pl. xxv, fig. 1–4.—Arber (1914 [1]), Q.J.G.S., lxx, p. 73, pl. ii, fig. 3.

Remarks.—Kidston and Lillie each recorded a single specimen of this very rare plant, of which only three or four British specimens are known. We have been fortunate in finding a number of specimens at various localities. Crenulation of the margin of the pinnule, mentioned by Arber (loc. cit.) as one of its outstanding features, is not necessarily present. When the character does occur, however, it distinguishes the plant very clearly.

Distribution.—*P. crenulata*, once thought to be restricted to the Radstockian Series, is now also known from the Staffordian and Westphalian (= Yorkian) [1] Series.

3. *Pecopteris volkmanni* Sauveur. (Pl. VIII, Fig. 4.)

Zeiller (1886–8), Valenc., p. 204, pl. xxviii, figs. 1–3.

Description.—Pinnae alternate, about 4 cm. long. Pinnules alternate, attached by the whole of their base, up to 9 mm. long and 2 mm. wide, entire, with rounded apex. Margins slightly flexuous. Median vein clearly marked up to the apex of the pinnule, slightly decurrent at the base, giving off lateral veins at an angle of 45 degrees, usually dividing into three veinlets.

Distribution.—*P. Volkmanni* is new to the coalfield. It has been recorded from the Yorkian, and this is the first record from the Staffordian Series.

4. *Pecopteris bucklandii* Brongniart.

Brongt., Hist. (1828), p. 319, pl. xcix, fig. 2.

Remarks.—This plant is extremely rare, having been collected previously at Camerton only. *P. bucklandii* has hitherto been known from the Radstock Group of the Radstockian Series only, and is here recorded for the first time from the Staffordian Series.[2]

5. *Pecopteris* (*Asterotheca*) *candolliana* Brongniart.

Brongt., Hist. (1828), p. 305, pl. c, fig. 1.—Potonié (1903), i, No. 10.

Remarks.—*P. candolliana*, another very rare species, has been found previously at two localities only in this coalfield. The specimens from Broad Oak and Bromley Collieries are the first to be recorded from the Staffordian Series.

ALETHOPTERIS Sternberg, 1826.

1. *Alethopteris* cf. *valida* Boulay.

Zeiller (1886–8), Valenc., p. 231, pl. xxxiii, figs. 1, 2; pl. xxxiv, fig. 1.—Kidst. (1905), Q.J.G.S., lxi, p. 311.—Potonié (1913), vii, No. 125.—Gothan (1913), i, p. 182, pl. xxxvii, fig. 4, text-fig. 12.

[1] W. W. Watts (1922), GEOL. MAG., LIX, p. 238.

[2] See p. 177.

Remarks.—Specimens collected at Broad Oak Colliery, Pensford, are assigned, with some doubt, to this species which has not been found before in the coalfield. *A. valida* has been found only once outside the Yorkian Series, Kidston (loc. cit.) recording it from the Blackband Group of the Staffordian Series in North Staffordshire.

2. *Alethopteris pontica* Zeiller. Fide Dr. Kidston.

Potonié (1913), ix, No. 169.

Remarks.—Three specimens which I had identified as *Alethopteris grandini* Brongt. sp. were assigned to *Alethopteris pontica* by Dr. Kidston, who remarked, however, that he was not sure whether these two species should not be united. The copied figure of *A. pontica* given by Franke (in Potonié, loc. cit.), is too unsatisfactory to form a basis for judgment, and I have not seen Zeiller's [1] original figure and description of his species. In the specimens identified as *A. pontica* the lateral veins leave the median vein at a sharper angle, and they are not quite so arched as in *A. grandini* as figured by Zeiller (Valenc., 1886–8, pl. xxxviii, figs. 1 and 2), but these differences are comparatively slight, and *A. grandini* as figured by Franke (in Potonié, 1913, ix, No. 168, fig. 1) also show these characteristics. The decurrence of the pinnule on the rachis in our specimens is somewhat variable. It seems to be quite probable that *A. pontica* Zeiller and *A. grandini* Brongt. sp. should be united; they are provisionally kept apart here.

Zeiller recorded a single specimen only of *A. pontica* and there are no other records of the species.

3. *Alethopteris* cf. *integra* Gothan sp.

Potonié (1906), iv, No. 64.—Kidst. (1914), Edinb., l, pp. 103–5, text-figs. 3, 4.

Remarks.—Fragments, which are provisionally referred to this species, were collected at Coalpit Heath Colliery. Kidston (loc. cit.) described and figured the only known British specimen of *A. integra*.

4. *Alethopteris grandini* Brongt. sp.

Brongt., Hist. (1828), p. 286, pl. xci, figs. 1–4.—Zeiller (1886–8), Valenc., p. 237, pl. xxxviii, figs. 1, 2.—Arber (1912), Phil. Trans. Lond., 202, p. 248, pl. xi, fig. 1.—Potonié (1913), ix, No. 186.—Arber (1914 [3]), Phil. Trans. Lond., 204, p. 391, pl. xxvi, fig. 6.

Remarks.—*A. grandini* is rare in Britain. It has been recorded from the Radstockian and Yorkian, and this is the first record of the species from the Staffordian Series.

SPHENOPTERIS Brongniart, 1822.

1. *Sphenopteris pecopteroides* Kidst.

Kidst. (1923), ii, pt. ii, p. 150, pl. xxxiii, figs. 1, 1*a*, 1*b*.

Remarks.—The specimens of *S. pecopteroides* here recorded from Parkfield Pit are the only ones known other than the type specimen.

[1] R. Zeiller (1889), Heraclée, S. 39, pl. iv, figs. 1, 1*a*.

2. *Sphenopteris ovatifolia* Lillie.

Lillie (1910), Geol. Mag., VII, p. 62, pl. vii, figs. 4, 5, text-figs. 1–3.—Kidst. (1923), ii, pt. ii, p. 151, pl. xxxiii, figs. 2, 2*a*–2*c*, 3.

Remarks.—A badly preserved fragment, collected at Coalpit Heath, is assigned, with some doubt, to Lillie's species. The veins run a straighter course than those of the type specimen. In another fragment, collected at Norton Hill Pit, the venation is more typical. The specimens are too fragmentary, however, to be determined with certainty.

3. *Sphenopteris laurenti* Andrae. (Pl. VI, Fig. 3.)

Zeiller (1886–8), Valenc., p. 85, pl. vi, fig. 3; pl. ix, fig. 4.—Potonié (1909), vi, No. 105.—Renier (1910), pl. lxv.—Vernon (1912), Q.J.G.S., 68, pl. lvii, fig. 2.—Gothan (1913), i, p. 134, pl. xvii, fig. 3.—Arber (1920), P. Yorks G.S., xix, p. 354, pl. xl, fig. 2.—Kidston (1923), pt. i, p. 69, pl. ix, figs. 1, 1*a*, 1*b*, 2; pl. x, figs. 1–3.

Remarks.—This species is here recorded for the first time from the coalfield. One specimen only has been found previously in the Staffordian Series. *S. laurenti* is fairly common in the Yorkian, rare in the Lanarkian Series.

4. *Sphenopteris dilatata*, L. & H.

Lindley & Hutton (1832), i, pl. xlvii.—Kidst. (1914), Edinb., l, p. 80, pl. v, figs. 1, 1*a*.—Kidst. (1923), ii, pt. i, p. 42, figs. 1–3.

Remarks.—A single well-preserved specimen of *S. dilatata* was collected at Deep Pit, the plant being new to the coalfield, and this being the first record from the Staffordian Series. The specimen, though fragmentary, confirms Kidston's view (op. cit., 1923, p. 43) that the nervation is rendered too closely in Lindley and Hutton's figure.

5. *Sphenopteris tenuissima* Presl.

Kidst. (1923), ii, pt. i, p. 94, pl. xxi, figs. 5, 6, 7, text-fig. 7.

Remarks.—*S. tenuissima* is new to the coalfield, and this constitutes the first record from the Staffordian Series, the plant having been met with, and that very rarely, in the Yorkian Series only. The pinnules are alternate, wedge-shaped, and strongly contracted at the base. The single fragment collected represents, no doubt, the lower portion of a pinna, the pinnules bearing several sharp teeth.

6. *Sphenopteris* (*Renaultia*) *chaerophylloides* Brongt. sp. (Pl. VI, Fig. 2.)

Brongt., Hist. (1828) p. 357, pl. cxxv, figs. 1, 2.—Zeiller, (1886–8), Valenc., p. 90, pl. xi, figs. 1, 2.—White (1899), Missouri, p. 49.—Renier (1910), pl. lxii.—Kidston (1923), ii, pt. iv, p. 315, pl. lxxviii, figs. 3–4.

Remarks.—As in the specimens described by Kidston (loc. cit.),

the nervation is not very clear, probably owing to the presence of hairs on the surface of the leaf, but *S. chaerophylloides* cannot easily be confused with any other species. The plant has not been recorded previously from the Staffordian Series.

7. *Sphenopteris* sp.

Remarks.—A single specimen of this plant was collected at Norton Hill Pit, near Midsomer Norton. The frond was evidently large. The pinnae are alternate, up to 3½ cm. long, pinnules alternate, decreasing in size towards the apex of the pinnae, directed forwards; each pinnule has several clearly marked lobes. A single vein enters each pinnule, and gives off lateral veins to each lobe. The venation is not very clear.

CORYNEPTERIS Bailey, 1860.

1. *Corynepteris* (*Zygopteris*) *sternbergi* Ettinghausen sp. (Pl. IX, Fig. 2.)

Zeiller (1886–8), Valenc., p. 128, pl. ix, fig. 5, pl. xxxviii, fig. 6.—Renier (1910), pl. lxxvii.—Vernon (1912), Q.J.G.S., lxviii, p. 637, pl. lviii, figs. 3, 5.—Kidst. (1923), ii, pt. iv, p. 301, pl. lxxiv, figs. 1, 2, 2*a*, 2*b*, 3, 5, 5*a–d*; pl. lxxviii, figs. 1, 1*a*, 2.

Alloiopteris (*Corynepteris*) *sternbergi* Gothan (1913), i, p. 113, pl. xxvi, figs. 2, 2*a*.

Remarks.—This species, collected at two localities (Broad Oak Colliery and Deep Pit) has not been found in the coalfield before, and this is the first record of *C. sternbergi* from the Staffordian Series. The plant is fairly rare in the Yorkian, and extremely rare in the Lanarkian, Series.

2. *Corynepteris* (*Zygopteris*) *coralloides* Gutber sp.

Zeiller (1886–8), Valenc., p. 117, pl. x, figs. 1, 5.—Arber (1910), P. Yorks G. Soc., xvii, p. 150, pl. xviii, fig. 3; pl. xix, fig. 2.—Renier (1910), pl. lxxix.—Gothan (1913), i, p. 111, pl. xxv, figs. 1–3.—Kidst. (1923), ii, pt. iv, p., 297, pl. xlix, fig. 4; pl. lxxiii, figs. 2–5; pl. lxxiv, figs. 4, 4*a*, text-fig. 21, B, B′.

Remarks.—A single specimen of *C. coralloides* was collected at Newbury Pit. It is new to the coalfield, and this is the second record of the plant from the Staffordian Series.

DIPLOTMEMA Stur., 1877.

1. *Diplotmema* sp.

Remarks.—The specimen, which is the only one found in the coalfield, shows equal dichotomy, one of the ultimate branches bearing ten pinnae on alternate sides of the stem. The longest pinna measures 2·5 cm. in length, and there is progressive diminution in length to the end of the branch. Pinnules small, contracted at the base, margin entire. Larger pinnules, towards the base of the pinnae, tend to dichotomise, and are about 6 mm. long and 3 mm.

broad. The veins are not well shown but appear to be few, and to fork once or twice. The pinnules are shorter and more rounded than in *D. furcatum* Brongt., as figured by Zeiller (Valenc., 1886–8, pl. iv, figs. 5, 6 ; pl. v, fig. 4) and by Brongniart (Hist., 1828, pl. xlix, figs. 4, 5). On the other hand, there is some resemblance to *Palmatopteris furcata* (Brongt.) *forma spinosa* as figured by Renier (1910, pl. lxxxi).

2. *Diplotmema furcatum* Brongt. sp.

Brongt., Hist. (1828), p. 179, pl. xlix, figs. 4, 5.—Zeiller (1886–8), Valenc., p. 147, pl. iv, figs. 5, 6 ; pl. v, fig. 4.—Kidst. (1923), ii, pt. iii, p. 255, pl. lxi, figs. 4, 5 ; pl. lxvii, fig. 1, text-fig. 16, p. 240.

Palmatopteris furcata Potonié (1904), ii, No. 21.—Renier (1910), pl. lxxx.—Gothan (1913), i, p. 77, pl. xvi, fig. 1.

Remarks.—D. furcatum is here recorded for the first time from the coalfield, and this is the first undoubted record of the species from the Staffordian Series.

NEUROPTERIS Brongniart, 1822.

1. *Neuropteris schlehani* Stur.

Zeiller (1886–8), Valenc., p. 280, pl. xlvi, fig. 3 ; pl. xlvii, figs. 1, 2.—Potonié (1907), v, No. 100.—Vernon (1912), Q.J.G.S., lxviii, pl. lviii, fig. 1.—Gothan (1913), i, p. 202, pl. xlix, figs. 2, 3; pl. liii, fig. 3.

A single specimen of *N. schlehani* was found at Broad Oak Colliery, Pensford, consisting of eleven alternate pinnules. Pinnules from 5 to 9 mm. long, 3 to 5 mm. wide, contour elliptical, with the apex tapering to an obtuse point, the widest part of the pinnule occurring at one-fourth its length from the base. The median vein is clearly marked and can be traced to the apex of the leaflet. The lateral veins, also clearly marked, leave the median vein at an acute angle, arch outwards, dichotomising two or three times, and make an angle of about 45 degrees with the margin of the pinnule.

N. schlehani is new to this coalfield. In the specimen recorded above, the long tapering apical pinnule, so characteristic of the species, is unfortunately absent. The pinnules are longer in proportion to their breadth than in *N. rarinervis* Bunb., and the veins are much more numerous and closer. In the Somerset specimen the pinnules are rather more sharply pointed than in those figured by Zeiller (loc. cit.).

Distribution.—N. schlehani is extremely rare in Britain. It has been recorded from the Yorkian, and this is the first record from the Staffordian Series. In some of the Continental coalfields *N. schlehani* is of fairly frequent occurrence.

2. *Neuropteris pseudogigantea* Potonié. (Pl. VII, Fig. 2.)

Kidst. (1914), Edinb., l, No. 5, p. 108, pl. vi, figs. 1–7.

Remarks.—*N. gigantea* Sternb. and *N. pseudogigantea* (= *N. zeilleri*) Potonié were united by Kidston (loc. cit.), but, following that author's suggestion, they are here provisionally kept separate. Among the specimens collected some of the pinnules are quite straight, others are slightly sickle-shaped. In some specimens the pinnules approach the typical *N. gigantea* form ("obliquely elongate, ovate cordate, narrowing towards the apex"), in others the margins are almost parallel (i.e. *pseudogigantea* form). The pinnules measure 13–14 mm. long by 6–8 mm. broad, i.e. the proportion of breadth to length accords with that of *N. pseudogigantea*. The middle vein can be clearly traced to beyond the centre of the pinnule, and breaks up into veinlets half-way up the pinnule. *N. pseudogigantea* is new to this coalfield, where it was found in both the New Rock and the Vobster Series.

3. *Neuropteris* cf. *raymondi* Zeiller.

Zeiller (1890), Autun, ii, pt. i, p. 147, pl. ix*a*, fig. 4.

Description.—The pinnules, which slightly overlap each other, are from 10–18 mm. long and from 6 to 8 mm. broad. Their lateral margins are almost parallel and the apex is rounded. The veins are clearly marked. The median vein, which is slightly decurrent at the base, is sometimes slightly flexuous. The lateral veins arch outwards, forking several times. Zeiller (loc. cit.) gives the dimensions of the pinnules of the type specimen as 10–15 mm. long and 4–8 mm. broad. The specimens here recorded and assigned, with some slight doubt, to this species are, on the whole, rather larger, but otherwise they agree well with Zeiller's figures.

Remarks.—If the determination is correct, this is the first record of *N. raymondi* from Great Britain. Zeiller's specimen lacked the terminal pinnules, so that he could not say whether they were larger or smaller than the others. In one of the specimens collected the terminal pinnule is shown, and measures 20 mm. long by 6 mm. broad.

ODONTOPTERIS Brongniart, 1822.

1. *Odontopteris conwayi* L. & H. sp.

L. & H. (1833–5), ii, pl. cxlvi.

Description.—Rachis 2 mm. wide; pinnae alternate, up to 5½ cm. long; the lateral edges of adjacent pinnae may or may not touch. Pinnules alternate, tapering towards the apex of the pinnae; up to 1 cm. long and 3 mm. broad. Median vein strongly marked and slightly decurrent at the base, giving off numerous lateral veins.

Remarks.—*O. conwayi* is new to the coalfield and has only twice been recorded from Britain.[1]

[1] R. Kidston (1894 [1]), Edinb., xxxvii, pt. iii, No. 26, p. 568.

2. *Odontopteris alpina* (Sternb.) Geinitz.

Kidst. (1901), Yorks G. & P. Soc., xiv, p. 196, pl. xxviii, fig. 1.—Potonié (1904), ii, No. 22, fig. 1.—Kidst. (1914), Edinb., I, p. 105.

Remarks.—A specimen of *O. alpina* was collected at Broad Oak Colliery. The plant is new to the coalfield and, I believe, to the Staffordian Series.

DESMOPTERIS Stur., 1883.

Desmopteris elongata Presl. (sp.).

Zeiller (1886–8), Valenc., p. 216, pl. xxxviii, figs. 3–5.

Description.—The specimen consists of a single pinnule attached to a longitudinally striated rachis. The sessile pinnule, which is slightly arched upwards, and the apex of which is lacking, is 2 cm. long and 6 mm. broad. The median vein is strongly marked and is slightly decurrent at the base. The lateral veins, which leave the median vein at an angle of about 50 degrees, fork at about one-third of the distance from the margin, and sometimes divide again. They are arched, especially in the lower part of the pinnule.

Remarks.—The species is extremely rare, and this is a new record from the Bristol and Somerset Coalfield.

SEMINA INCERTAE SEDIS.

TRIGONOCARPUS Brongniart, 1825.

Trigonocarpus parkinsoni Brongt.

L. & H. (1832), iii, pl. ccxxii, figs. 1, 3.—Kidst. (1902), P. Yorks G. & P. Soc., xiv, p. 367, pl. lxv, figs. 1–3.—Kidst. (1911), Belge, p. 249, text-figs. 38–41.—Arber (1914 [2]), A. of B., xxviii, pp. 84, 94, pl. vi, figs. 2–5.

Description.—Seeds 20–22 mm. long, 17–19 mm. broad, tapering gradually towards a bluntly pointed apex. The greatest width occurs slightly below the middle line.

Remarks.—These seeds are very similar to *Trigonocarpus olivaeforme* L. & H., but Kidston (" Catalogue," 1886, pp. 218–19) showed that *T. olivaeforme* is one of the three conditions of preservation of *Trigonocarpus parkinsoni* Brongt., being the state in which " the more delicate ridges have become obliterated ".[1] *T. parkinsoni* has a wide distribution in the British Coal Measures, being recorded from the Staffordian, Yorkian, and Lanarkian Series of many coalfields.

HOLCOSPERMUM Nathorst, 1914.

Holcospermum mamillatum Lesquereux sp. (Pl. VI, Figs. 4, 5.)

Lesqx. (1879), Pennsylv., pl. lxxxv, figs. 32, 33, 33*a*.

Description.—Seed symmetrical, 12–13 mm. long, 6–7 mm. broad. Testa bearing prominent longitudinal ridges which take a slightly

[1] See also Scott and Maslen (1907), A. of B., xxi, p. 93.

flexuous course, some traverse the whole length of the seed, others do not.

Remarks.—This very distinctive seed is new to the coalfield and has been found twice only in Great Britain. It was collected at one locality only, namely, Broad Oak Colliery, Pensford, where it occurs invariably associated with the leaves of several species of *Neuropteris*.

LYCOPODIALES.

Sigillaria Brongniart, 1822.

1. *Sigillaria kidstoni* n. sp. (Pl. VI, Fig. 1.)

Description.—Ribs 23–25 mm. apart, slightly flexuous, clearly marked. Vertical distance between successive leaf-scars varies from 12 to 20 mm. Leaf-scars 6–9 mm. wide, 3–4½ mm. high; lateral angles rounded, upper margin emarginate, lower margin rounded. A transverse line 6–8 mm. long occurs above some of the leaf-scars, and immediately above the leaf-scar is the ligular cicatricule. The three foliar cicatricules are placed at about one-third from the top of the scar, the lateral (parichnos) being obscured in almost every case by coaly matter. The grooves between the ribs are marked with a number of distinct longitudinal and oblique wrinkles. Numerous transverse wrinkles, 3 to 5 mm. long, also occur immediately beneath the leaf-scar and extend in a vertical file almost to the scar below.

Remarks.—In the form of the leaf-scars and in the general structure *S. kidstoni* most nearly approaches *S. reniformis* Brongt. (Hist., 1828, pl. cxlii), but the well-marked and regular ornamentation of the grooves separates it at a glance from that species. The leaf-scars of *S. kidstoni* are not so high in proportion to their width as those of *S. reniformis*, and the lateral angles are considerably less-rounded, while no descending lines are given off from them. Lastly, in *S. reniformis*, the middle of the grooves is always smooth, while in our specimen a series of distinct transverse markings is visible.

2. *Sigillaria rugosa* Brongniart.

Brongt., Hist. (1828), i, p. 476, pl. cxliv, fig. 2.—Zeiller (1886–8), Valenc., p. 551, pl. lxxx, figs. 1–5.—Kidst. (1902), P. Yorks G. & P. Soc., xiv, p. 354, pl. lxi, fig. 1.

Remarks.—In a few of the specimens, which are probably young branches, the scars occupy the whole width of the grooves, and the grooves are convex, while the lines leaving the lateral angles of the leaf-scars cannot be observed. In the older stems the grooves are flat and the leaf-scar occupies one-third to a half of their width. *S. rugosa* has not been recorded before from this coalfield, where it is rare, though occurring at several localities. The species is known from the Staffordian, Yorkian, and Lanarkian Series.

3. *Sigillaria deutschiana* Brongniart. (Pl. VIII, Fig. 3.)

Brongt., Hist. (1828), i, p. 457, pl. clxiv, fig. 3.—Zeiller (1886–8), Valenc., p. 554, pl. lxxx, figs. 6–8.—Arber (1916), P. Trans. Lond., ccviii, p. 148, pl. iv, fig. 17.

Remarks.—*S. deutschiana* is new to the coalfield where it is extremely rare, two specimens only being collected.

In the present specimens the leaf-scars are larger than usual, being 8 mm. high by 7 mm. wide. Zeiller (loc. cit.) gives the dimensions as 4–6 mm. high by 3–5 mm. wide. Our specimens agree with Arber's (loc. cit.), and differ from Zeiller's and Brongniart's (loc. cit.), in that the lines arising from the lateral angles of the scars disappear a short distance below the scar, and are not continued to the scar below. They agree, however, with Brongniart's and Zeiller's specimens (and differ from Arber's) in the upper margin of the scar being only slightly emarginate.

Distribution.—This is a new record from the Staffordian Series, *S. deutschiana* having been found only in the Yorkian Series (where it is rare).

4. *Sigillaria transversalis* var. *sparsifolia* Boulay.

Brongt., Hist. (1828), i, p. 450, pl. clix, fig. 3.—Zeiller (1886–8), Valenc., p. 531, pl. lxxxviii, fig. 1.—Arber (1914 [3]), P. Trans. Lond., cciv, p. 398, pl. xxviii, fig. 19.—Kidst. (1917), Edinb., li, p. 1054, pl. ii, figs. 2–4.

Description.—Ribs straight or slightly flexuous, not strongly marked, 9 to 10 mm. apart. Leaf scars 4 to 5 mm. high, 5 to 6 mm. wide. Vertical distance between successive leaf-scars, 18 to 19 mm. Lateral angles of leaf-scar rounded; upper margin emarginate, lower margin rounded. The three foliar cicatricules occur about one-third down the scar, the central being punctiform, and the two lateral (parichnos) elliptical, 2 mm. long. Ligular cicatricule immediately above the leaf-scar. To the naked eye the grooves between the ribs appear smooth, but, seen under the lens, they are ornamented by extremely fine vertical and oblique lines.

Remarks.—A single specimen of this rare plant, which is new to the coalfield, was collected at Broad Oak Colliery, Pensford.

In the examples figured by Brongniart and Arber (loc. cit.) the lateral angles of the leaf-scar are quite sharp; in those figured by Zeiller and Kidston (loc. cit.) they are rounded and agree in this respect with the specimen in hand.

5. *Sigillaria nortonensis* n.sp. (Pl. VII, Fig. 1.)

Description.—Ribs 14–15 mm. apart, very clearly marked, straight. Vertical distance between successive leaf-scars, 13–15 mm. Leaf-scars hexagonal, 7 mm. high, 8 mm. broad, lateral angles rounded; upper margin very slightly depressed in the middle, lower margin rounded. Immediately above the leaf-scar is the ligular cicatricule, above which is a clearly marked transverse line 5–6 mm. long, curving slightly in the middle towards the leaf-scar. The three foliar cicatricules, which are situated one-third the distance down the scar, are plainly visible, the central (vascular) being semi-lunar

and the two lateral (parichnos), elliptical, 1 mm. long. There is no ornamentation of the grooves between the ribs.

Remarks.—The single specimen, collected at Norton Hill Pit, near Midsomer Norton, is very well preserved.

The difference between *S. nortonensis* and *S. sauveuri* Zeiller (1886–8, Valenc., p. 559, pl. lxxxiv, figs. 1–3) are shown in the following table :—

S. sauveuri.	*S. nortonensis.*
Scars higher than wide . . . (4–7 mm. high, 3–6 mm. wide.)	Scars broader than high.
Grooves ornamented by short fine lines.	Grooves smooth.
Straight transverse line above leaf-scar.	Transverse line above leaf-scar is depressed in centre.

Compared with *S. tessellata* (Zeiller, 1886–8, Valenc., p. 561, pl. lxxxv, figs. 1–9 ; pl. lxxxvi, figs. 1–6) we note the following differences :—

S. tessellata.	*S. nortonensis.*
Scars generally higher than wide . (5–8 mm. high, 4–7 mm. wide.)	Above.
Lateral angles of scar slightly rounded	Lateral angles more rounded.
Lower margin of scar fairly straight .	Lower margin round.
Straight transverse line above leaf-scar.	Above.

6. *Sigillaria tessellata* Stein. sp.

Brongt., Hist. (1828), p. 436, pl. clxii, figs. 1–4.—Zeiller (1886–8), Valenc., p. 561, pl. lxxxv, figs. 1–9 ; pl. lxxxvi, figs. 1–6.—Potonié (1903), i, No. 20.—Arber (1904), P. Trans. Lond., cxcvii, p. 308, pl. xix, fig. 7.

Remarks.—Kidston (1887, p. 397) recorded *S. tessellata* from the Bristol and Somerset Coalfield, but later (Kidston, 1905, Q.J.G.S., lxi, p. 317) pointed out that these specimens were *S. cumulata* Weiss. In the present work specimens of *S. tessellata* were collected at various localities, and this is therefore the first record of the species from the coalfield.

7. *Sigillaria cordigera* Zeiller.

Zeiller (1886–8), Valenc., p. 526, pl. lxxviii, fig. 5.—Kidst. (1914), Edinb., l, p. 144, pl. xi, figs. 5, 5*a*.

Remarks.—*S. cordigera* is new to the coalfield. It is very rare on the Continent and has been recorded from Britain once only (Yorkian

Series), this being the first record of the plant from the Staffordian Series. The cordate leaf-scars are very distinctive.

8. *Sigillaria* cf. *germanica* Weiss. Fide Dr. Kidston. (Pl. VIII, Fig. 1.)

1887. *Sigillaria germanica* Weiss, D. Sigillar d. Preuss, Steinkohl., Abh. 2, Geol. Spec. v. Preuss., Bd. vii, Heft. iii, p. 38, pl. xi, figs. 57–9.*

Description.—Ribs 10–12 mm. apart; vertical distance between successive leaf-scars 20 mm.; leaf-scars oval-hexagonal, slightly emarginate above, 8–9 mm. wide, 7 mm. high. Ligular cicatricule visible, above which is a transverse line. The three foliar cicatricules are placed a little above the middle of the leaf-scar.

Remark.—Providing the determination of the specimens is correct, this is the first British record of the species.

9. *Sigillaria mauricii* Grand 'Eury. Fide Dr. Kidston. (Pl. IX, Fig. 3.)

1890. *Sigillaria mauricii* Grand 'Eury, Geol. et Pal. d. Bassin Houil. du Gard, p. 248, pl. v, figs. 10–11; pl. xi, fig. 8; pl. xiii, figs. 1*c*, 3, 4, 4′, 5, 7*b*.*

Description.—Ribs 8–12 mm. apart, strongly marked, not straight, but following the outline of the leaf-scars. Leaf-bases 7–8 mm. wide, 8 mm. high, 13–14 mm. apart vertically lateral angles sharp. Lower angle rounded, upper margin emarginate. The three foliar cicatricules are clearly visible and are situated at about three-fifths the distance up the leaf-scar.

Remark.—*S. mauricii* is a new record from Great Britain.

10. *Sigillaria ovata* Sauveur. (Pl. VIII, Fig. 2.)

Zeiller (1886–8), Valenc., p. 522, pl. lxxix, figs. 4–7.

Description.—The average distance between the ribs is 11 mm. Vertical distance between successive leaf-scars averages 23 mm. Leaf-scars, oval, 8–9 mm. long, 6–7 mm. broad. Short descending lines leave the lateral angles of some of the scars. Ligular cicatricules clearly visible above leaf-scar. Foliar cicatricules placed a little above the middle of the leaf-scar, the central (vascular) being punctiform and the two lateral elliptical, 2 mm. long. A little above the ligule are indications of one or more transverse lines 2–3 mm. long, but these are barely visible.

Remarks.—While there is no doubt as to the determination of these fossils, the specimens show one or two minor differences from *S. ovata* Sauveur as figured by Zeiller :—

1. The lateral (parichnos) cicatricules are given by Zeiller (loc. cit.) as being 1–1½ mm. long. In our specimens they are fully 2 mm. long, and thus, instead of having the oval appearance as shown in Zeiller's enlargement (fig. 5*a*), they are elongated ellipses.

* I am indebted to Mr. W. N. Edwards, of the British Museum, for this reference, having been unable to consult the work.

2. Zeiller's figures show no descending lines leaving the angles of the scars, and he regards this as one of the characters distinguishing *S. ovata* from *S. laevigata* (op. cit., p. 523). Curved lines, 7–8 mm. long, are visible on some of the scars in our fossils, their presence being probably correlated with the fact that the lateral angles are rather sharply marked.

3. The fine oblique lines on the grooves just beneath the leaf-scars are lacking in our specimens, but these are not always present in *S. ovata*.

4. Zeiller (op. cit., p. 524) regarded the absence of a transverse line about the scar as one of the characteristics which distinguish *S. ovata* from *S. walchi* Sauveur, but in the specimens in hand there are, above some of the scars, faint transverse lines.

S. ovata is a new record from this coalfield. It is known chiefly from the Yorkian Series and this is the second record from the Staffordian Series.

11. *Sigillaria saulii* Brongt.

Brongt. (1828), Hist., p. 456, pl. cli.—Kidston (1911), Belge, p. 200, pl. xxii, fig. 2.

Remarks.—*S. saulii* has been known hitherto only from the Yorkian, and this is the first record from the Staffordian Series. Kidston (loc. cit.) pointed out that, while in Brongniart's specimen the bark bore transverse wrinkles, in the Belgian specimen it was quite smooth. The specimen here recorded bears a few transverse marks.

LEPIDODENDRON Sternberg, 1820.

1. *Lepidodendron* cf. *jaraczewskii* Zeiller.

Zeiller (1886–8), Valenc., p. 457, pl. lxvii, fig. 3.—Potonié (1906), iv, No. 78.

Description.—The leaf bases are contiguous, projecting, elongate rhomboidal, averaging 30 mm. long and 7 mm. broad, the lateral angles rounded, and the upper and lower angles slightly inflected. The leaf-scar is situated at about 10 to 12 mm. from the top of the leaf-base, and is small and not well-preserved. The keel is clear and continuous, and without transverse markings. The upper portion of the scar has also a clearly marked continuous keel.

Remarks.—The specimens, though not well preserved, agree well in size and general form with Zeiller's figure (loc. cit.). If the determination is correct, this is the first record of the species from the Bristol Coalfield and from the Staffordian Series.[1]

2. *Lepidodendron rimosum* Sternberg.

Schimper (1869–74), Traité, ii, p. 35, pl. lx, fig. 8.—Zeiller (1886–8), Valenc., p. 449, pl. lxvii, fig. 4.—Potonié (1906), iv, No. 74.

Description.—The rhomboidal leaf-bases, which project but

[1] See p. 177.

slightly, average 15 mm. in length and 3 mm. in breadth. Lateral angles rounded ; upper and lower angles sharply pointed and quite straight. Surrounding each leaf-base is a rim of about 7 mm. bearing clear longitudinal markings. Leaf-scar situated at about 8 mm. down the leaf-base, not clearly marked.

Remarks.—The above description refers to a decorticated specimen, from Hanham Colliery, which has a great resemblance to the specimen figured by Zeiller (loc. cit.). A specimen, which is much better preserved, was collected at Coalpit Heath, but this is of a young branch, the leaf-bases being 5 mm. long only. *L. rimosum* is distinguished from all other species of the genus by the ornamented rim surrounding the leaf-bases.

Distribution.—*L. rimosum* is rare in Britain, and is known from the Staffordian, Yorkian, and Lanarkian Series.

3. *Lepidodendron loricatum* Arber (*pars*).

Arber (1922), J. Linn. Soc., xlvi, p. 201, pl. xiii, figs. 27–37.

Description.—The leaf-bases are 5 mm. long by 4 mm. broad, and the leaf-scars 3 mm. broad by 2 mm. high. The keel, which is slight, occasionally bears two or three small transverse marks. No lines leave the lateral angles of the scars. The prints of the leaf-scar are distinctly seen.

Remarks.—This plant, the *Lepidodendron dichotomum* Sternb., of Zeiller, has not been known hitherto from the coalfield. The present record is the third from the Staffordian Series, the species being found chiefly in the Yorkian and Lanarkian Series.

4. *Lepidodendron distans* Lesquereux. (Pl. IX, Fig. 4.)

Kidst. (1914), Edinb., l, p. 135. *Lepidodendron serpentigerum* Kidst. (1902), P. Yorks G. & P. Soc., xiv, p. 346, pl. li, fig. 2.—Potonié (1906), iv, No. 75.

Remarks.—Two or three specimens only of this plant have been found in Great Britain (Yorkian and Lanarkian Series), and this is the first record from the Staffordian Series. The specimen is quite typical and well preserved. It was originally known as *Lepidodendron serpentigerum* Konig, but the description and figure were not published under that name.

5. *Lepidodendron obovatum* Sternberg. (Pl. VII, Fig. 4.)

Zeiller (1886–8), Valenc., p. 442, pl. lxvi, figs. 1–8.

Description.—Leaf-bases 9–10 mm. long, 7–8 mm. broad. Leaf-scars 3 mm. high by 4 mm. broad. Transverse markings on the keel absent or almost absent.

Remarks.—*L. obovatum* has not been found in the Bristol and Somerset Coalfield before. It is known chiefly from the Yorkian and Lanarkian Series, and this is the second Staffordian record.

6. *Lepidodendron ophiurus* Brongniart.

Zeiller (1886–8), Valenc., p. 458, pl. lxviii, figs. 1–6.—Potonié (1906), iv, No. 73.—Arber (1922), J. Linn. Soc., xlvi, p. 197, pl. xii, figs. 23–6.

Remarks.—This, the first record of *L. ophiurus* from the coalfield, is the second from the Staffordian Series, the species having been known chiefly from the Yorkian and Lanarkian Series. The differences between the three species, *L. lanceolatum*, *L. obovatum*, and *L. ophiurus* were discussed and tabulated by Arber (op. cit., p, 205).

LEPIDOSTROBUS Brongniart, 1828.

1. *Lepidostrobus triangularis* (Zeiller).

Zeiller (1886–8), Valenc, p. 508, pl. lxxvii, figs. 4–5.—Arber (1922), J. Linn. Soc., lxvi, p. 185, pl ix, figs. 32, 33.

Description.—Lamina 15 mm. long by 10 mm. broad, apical and lateral angles sharp. The wedge-shaped pedicel measures 5 mm. long by 5 mm. broad.

Remarks.—*L. triangularis* has not been found previously in the coalfield. Its known distribution has hitherto been confined to the Yorkian Series, and this is the first Staffordian record.

2. *Lepidostrobus brevifolius* (Lesqx.).

Kidst. (1887), Edinb. xxxiii, p. 395, pl. xxvii, fig. 7.—Arber (1912), Trans. Soc. Lond., 202, p. 252.—Arber (1922), J. Linn. Soc., xlvi, p. 177, pl. viii, figs. 4–8.

Remarks.—*L. brevifolius* is readily distinguished from *L. minor* Goode, which is of about the same size, by the narrow pedicel 8–10 mm. long, and by the blunter angles of the lamina, which give it a spade-like appearance. It is known from the Radstockian Series, and is here recorded for the first time from the Staffordian Series.

3. *Lepidostrobus minor* (Goode).

Goode (1913), Q.J.G.S., lxix, p. 266, pl. xxviii, figs. 3, 5.—Arber (1922), J. Linn. Soc., xlvi, p. 183, pl. ix, figs. 22–5.

Remarks.—Although widely distributed throughout the coalfield, these sporophylls have not been recorded previously. A specimen collected at Norton Hill Pit, in which the sporophylls are attached to the cone axis, is the first to be recorded in this condition. Some of the larger specimens of *L. minor* approach in size *L. triangularis* Zeiller,[1] and the specimens of the latter species, as figured by that author, vary in length from 17 to 23 mm. The form of the bracts in these two species is very similar and it seems very probable that they should be united.[2] They are kept apart provisionally here.

[1] Zeiller, R. (1886–8), Valenc., pl. lxxii, figs. 4–6.
[2] See R. Kidston (1890–1), *Yorks Nat. Union*, xiv, p. 51.

Distribution.—Hitherto *L. minor* Goode has been known chiefly from the Yorkian Series, and this is the second record from the Staffordian Series.

4. *Lepidostrobus majus* Brongt. sp.

L. & H. (1835), ii, pl. clii.—Schimper (1869–74), Traité, ii, p. 72, pl. lxiv, fig. 9.—Kidst. (1887), Edinb., xxxiii, p. 395,—Kidst. (1911), Belge, iv, p. 154.—Arber (1922), J. Linn. Soc., xlvi, p. 182, pl. viii, fig. 20; pl. ix, fig. 21.

Remarks.—Comparing the specimens of *L. majus* collected with the figure of *Lepidostrobus missouriensis* White (1899, Missouri, pl. lx), I believe the latter species should be united to *L. majus* Brongt.

Distribution.—*L. majus* occurs throughout the Coal Measures of Great Britain. It is fairly rare in this coalfield.

5. *Lepidostrobus morissianum* Lesquereux sp.

Lesq. (1879), Pennsylv., ii, p. 448, pl. lxix, fig. 41.

Description.—The specimens are from 14 to 20 mm. long, and 4–6 mm. broad at the widest part (which occurs just above the pedicel). The pedicel is triangular, about 2 mm. long and 2 mm. broad, lower angle acute. The lamina tapers to a very acute point, taking a characteristic oblique course. The single vein is distinctly visible.

Remark.—This is the first record of the species from Great Britain.

6. *Lepidostrobus incertus* Lesquereux.

Lesq. (1897), Pennsylv., pl. lxix, fig. 25.

Description.—The specimens have a total length of 6 to 10 mm., the pedicel being 1 mm. long. The lamina, which has a sharply pointed apex and bears a single vein, measures 2 mm. across at its widest part (slightly below half-way).

Remark.—*L. incertus* has not been recorded from this country before.

Stigmaria Brongniart, 1822.

Stigmaria minuta Göppert.

Stigmaria eveni Lesqx. (1879), Pennsylv., p. 16, pl. lxxiv, fig. 1.—*Stigmaria minuta*, Kidst. (1916), Edinb., li, p. 717, pl. iii, fig. 6.

Remarks.—*S. minuta* has not been found previously in the coalfield. The species is distinguished from *S. minor* Geinitz [1] (a single specimen of which has been recorded from this coalfield) (Kidston, 1887, p. 401) by the extremely small rootlet scars.

Distribution.—This is the first record of *S. minuta* from the Staffordian Series. It is also known from the Yorkian (where it is fairly rare) and the Lanarkian Series (where it is very rare).

[1] *Stigmaria ficoides* var. *minor* Geinitz, *Vers. D. Steinkf. in Sachsen.*, p. 49, pl. iv, fig. 6; pl. x, fig. 1, 1855.

Lycopod megaspores.

Remark.—I have often found *Lycopod megaspores* accompanying *Sigillarias* only, and this at three localities, namely, Deep, Hanham, and Coalpit Heath Collieries.

LEPIDOPHLOIOS Sternberg, 1825.

Lepidophloios laricinus Sternb.

Schimper (1869–74), Traité, ii, p. 51, pl. lix, fig. 4; pl. lxiv, figs. 4, 6, 8.—Zeiller (1886–8), Valenc., p. 471, pl. lxxii, figs. 1–3.—Kidst. (1893 [3]), Edinb., xxxvii, pt. iii, No. 25, p. 556, pl. i, fig. 4.—Kidst. (1902), P. Yorks G. & P. Soc., xiv, pl. lvi, fig. 2.

Remarks.—This is the first record of *L. laricinus* from the coalfield. Typical specimens were collected at Norton Hill, Parkfield, and Coalpit Heath Collieries, and a somewhat doubtful specimen was obtained from the "Millstone Grit" at Yate.

Distribution.—*L. laricinus* is very rare in the Staffordian Series, and fairly rare in the Yorkian Series.

EQUISETALES.

ASTEROPHYLLITES Brongniart, 1822.

Asterophyllites grandis Sternberg sp.

Zeiller (1886–8), Valenc., p. 376, pl. lix, figs. 4–7.—*Berchera grandis* L. & H. (1826), iii, pl. clxxiii.

Remarks.—Isolated twigs of *A. grandis* were found at Deep Pit. The nodes of the ultimate branches average 3 mm. in length, the leaves are linear, curving outwards, 3–4 mm. long, and ending in sharp points. Although Kidston [1] has remarked that this species is probably "not distinct from *Calamocladus equisetiformis* Schl. sp.", the two "species" have always been recorded separately by that author. Zeiller regarded them as distinct. This, the first record of the plant from the Bristol and Somerset Coalfield, is the second record from the Staffordian Series.

PINNULARIA Lindley & Hutton, 1834.

Pinnularia capillacea L. & H.

L. & H. (1832), ii, pl. iii.—*Radicites capillacea* Renier (1910), pl. liv.

Remarks.—All the roots collected in the present work are placed under *Pinnularia capillacea* L. & H. or *Pinnularia columnaris* Artis sp. *Pinnulariae* are the roots and rootlets of several Coal Measure plants, including *Calamites*.

MACROSTACHYA Schimper, 1869.

Macrostachya cf. *infundibuliformis* Brongniart sp.

Schimper (1869–74), Traité, i, p. 133, pl. xxiii, figs. 15, 16, 17.—Kidst. (1887), Edinb., xxxiii, p. 344.—*Equisetum infundibuliforme* Brongt. (1828), Hist., p. 119, pl. xii, figs. 14, 15.

[1] R. Kidston (1885), *Ann. and Mag. Nat. Hist.*, p. 479.

Remarks.—A single specimen probably of this cone was collected at Coalpit Heath. The species is extremely rare, and, if the determination is correct, this is the second record from the Staffordian Series.

SPHENOPHYLLALES.

Sphenophyllum Brongniart, 1822.

1. *Sphenophyllum cuneifolium* Sternb.

Sphenophyllum erosum Schimper (1869–74), Traité, i, p. 341, pl. xxv, figs. 10–14.—*Sphenophyllum cuneifolium* Zeiller (1886–8), Valenc., p. 413, pl. lxii, fig. 1; pl. lxiii, figs. 1–10.—Renier, (1910), pl. lvi.

Remarks.—This is the first record of *S. cuneifolium* from the Bristol and Somerset Coalfield. The species is easily distinguished from the common *S. emarginatum* by the sharp triangular teeth on the margins of the leaves, and by the concave lateral edges of the leaflets.

Specimens of *Sphenophyllum cuneifolium* forma *saxifragaefolium* were also collected, though this form is much rarer.

Distribution.—*S. cuneifolium* is known from the Staffordian Series, where it is rare, and from the Yorkian and Lanarkian Series, where it is common.

2. *Sphenophyllum trichomatosum* Stur.

Kidst. (1890–1), Edinb., xi, pp. 56–62, pl. i, figs. 1–4.

Remarks.—*S. trichomatosum* has been known from the Yorkian Series only, and this, the first record from the coalfield, is also the first record from the Staffordian Series.

3. *Sphenophyllum myriophyllum* Crépin.

Zeiller (1886–8), Valenc., p. 422, pl. lxi, fig. 7; pl. lxii, figs. 2–4.—Kidst. (1902), P. Yorks G. & P. Soc., xiv, p. 360, pl. lxiii, fig. 2.—Renier (1910), pl. lvii.—Arber (1914 [1]), Q.J.G.S., lxx, p. 70, pl. xii, fig. 1.

Remarks.—*Sphenophyllum myriophyllum* collected at Deep Pit, Kingswood, is also a new record from the coalfield, where it is extremely rare. It has been recorded once before from the Staffordian Series, and is found chiefly in the Yorkian Series.

4. *Sphenophyllum longifolium* Germar.

Zeiller (1906), Blanzy, p. 122, pl. xxxvi, figs. 1–3.

Remarks.—This plant has not been recorded previously with certainty from the coalfields of Great Britain. Some of the specimens collected are very typical, others are assigned with some doubt to *S. longifolium*.

CORDAITALES.

Poacordaites Grand 'Eury, 1877.

Poacordaites microstachys Goldenberg sp.

Kidst. (1887), Edinb., xxxiii, p. 402.—Kidst. (1902), P. Yorks G. & P. Soc., xiv, p. 364, pl. lvii, fig. 3.

Remarks.—A single specimen of *P. microstachys* was collected at Broad Oak Colliery, Pensford, and this is the first Staffordian record of the species.

Cordaites Unger, 1850.

1. *Cordaites angulosostriatus* Kidston (? Grand 'Eury). Fide Dr. Kidston.

Remarks.—Kidston (1887, p. 402) observed that this species is "generally distributed throughout the whole of the Radstock Series", but, when visiting Bristol, he remarked that there is some doubt as to the specific determination of these leaves. Dr. Kidston, however, identified a specimen, collected at Broad Oak Colliery, as *C. angulosostriatus* Kidst. I have not seen figures or descriptions of this species.

2. *Cordaites principalis* Germar sp.

Zeiller (1886–8), Valenc., p. 629, pl. xciii, fig. 3; pl. xciv, fig. 1.—Kidst. (1893 [2]), Edinb., xxxvii, pt. ii, No. 16, p. 352, pl. ii, figs. 8, 8*a*, ; pl. iv, figs. 16, 17.—Kidst. (1902), P. Yorks G. & P. Soc., xiv, p. 363, pl. liii, fig. 1; pl. lvii, fig. 2; pl. lxiv, fig. 3.—Kidst. (1914), Edinb., l, p. 151.

Remarks.—The chief distinguishing feature of the species consists in a number of strongly marked parallel veins running down the leaf, between each pair of which are 1 to 5 (usually 3 to 5) fine parallel lines.

This, the first record of *C. principalis* from the coalfield, is the third from the Staffordian Series. It is known chiefly from the Yorkian and Lanarkian Series.

3. *Cordaites borassifolius* Sternberg sp.

Zeiller (1886–8), Valenc., p. 629, pl. xciii, fig. 3; pl. xciv, fig. 1.—Kidst. (1911), Belge, p. 232.—Kidst. (1914), Edinb., l, p. 150.

Remarks.—*C. borassifolius* is here recorded for the first time from the coalfield, and this is the second Staffordian record. It is also known from the Radstockian, Yorkian, and Lanarkian Series.

Dorycordaites Grand 'Eury, 1877.

Dorycordaites palmaeformis Göpp. sp.

Zeiller (1886–8), Valenc., p. 632, pl. xciii, figs. 1, 2.—Kidst. (1902), P. Yorks G. & P. Soc., xiv, p. 364, pl. lxxvii, fig. 3.—Kidst. (1914), Edinb., l, p. 151.—Arber (1914 [1]), Q.J.G.S., lxx, p. 75, pl. xiii, fig. 6.

Remarks.—These very rare leaves, characterized by equally fine,

close, parallel veins, have not been found before in this coalfield, and the present is the first Staffordian record of the species.

CORDAICARPUS Geinitz, 1862.

1. *Cordaicarpus areolatus* (Boulay).

Zeiller (1886–8), Valenc., p. 646, pl. xciv, fig. 12.—Arber, (1914), Ann. of Bot., xxviii, p. 100, text-fig. 7.—Kidst. (1917), Edinb., li, p. 1062, pl. v, figs. 1, 1*a*.

Description.—Oval seed, very slightly tapering at one end; 8 mm. long by 6 mm. broad. The testa is marked with large polygonal meshes.

Remarks.—*C. areolatus* is very rare, having been recorded twice only from Britain. We here record it for the first time from the Staffordian Series. The peculiar reticulation of the surface was thought by Kidston [1] to be due to crumpling of the pericarp.

2. *Cordaicarpus cordai* (Gein.) sp.

Zeiller (1886–8), Valenc., p. 645, pl. xciv, fig. 13.—Kidst. (1902), P. Yorks G. & P. Soc., xiv, pl. lviii, fig. 4.—Kidst. (1903), Edinb., xi, p. 800, pl. i, figs. 12, 13.—Vernon (1912), Q.J.G.S., lxviii, pl. lviii, fig. 7.—Arber (1914 [2]), Ann. Bot., xxviii, p. 100, pl. vii, fig. 29.

Description and Remarks.—Seeds oval, 10 mm. long by 8 mm. broad. Testa smooth. The seed is generally surrounded by a narrow border.

This is the second record of *C. cordai* from the Staffordian Series. Geinitz regarded it as the fruit of *Cordaites principalis*, but Kidston [2] thought *Cordaianthus pitcairniae* L. & H. more likely to be the fruit of that plant.

FUNGI.

EXCIPULITES Göppert, 1836.

Excipulites callipteridis Schimper sp.

Schimper (1869–74), Traité, i, p. 142, pl. xxxii, figs. 6, 7.

Remarks.—Kidston (1887, p. 339) recorded these minute parasitic fungi as occurring on the leaves of *Sphenopteris neuropteroides* Boulay, from Radstock, and I have found them on the same species collected at Pensford. The presence of *Excipulites* on *Sphen. neuropteroides* has been observed also in France and America, so that these leaves seem to have been particularly liable to the disease. I have found *Excipulites* also on *Sphenopteris pecopteroides* Kidst. and *Dicksoniites pluckenetii* Schloth sp., both collected at Parkfield Colliery.

A specimen of *Neuropteris macrophylla* Brongt., collected at Broad Oak Colliery, Pensford, showed evidence of a sub-epidermal fungus

[1] R. Kidston (1893 [1]), *T. Yorks Nat. Union*, pt. xviii, p. 119.
[2] R. Kidston (1893 [3]), Edinb., xxxvii, pt. ii, No. 16, p. 354.

(not *Excipulites*), large tracts of the epidermis being raised above its normal level by the disease.

It will be observed, from the above, that the seams worked at four collieries (Parkfield, Coalpit Heath, Broad Oak, and Bromley Collieries) have been referred to the Staffordian Series. The justification for this, and for other determinations, will be given in the second part of this paper, when the entire coalfield has been worked over.

I am extremely grateful to the various colliery owners and managers for granting me all facilities to visit and collect at their pits. In particular, I would like to mention Mr. Sharp, manager of Hanham and Parkfield Pits, and his under-manager, Mr. Owen; Mr. Eames, manager of Coalpit Heath Colliery, and his under-manager, Mr. Sage; Mr. J. Smith, manager of Broad Oak and Bromley Collieries, and Mr. Moody, manager of Bishop Sutton New Pit.

My sincere thanks are due to Miss E. M. Lee for constant advice and help, and to Professor O. V. Darbishire for his interest in the work.

I am extremely grateful to the Bristol University Colston Research Society, which has borne the heavy cost of the plates, and the cost of travelling when collecting specimens.

During the course of this investigation I have been in receipt of a maintenance grant from the Department of Scientific and Industrial Research.

VIII. Summary.

(1) 510 plants are recorded from various localities in the coalfield, fossils having been collected from several new localities.

(2) Fossil-plants are noted for the first time from the upper beds of the "Millstone Grit" of this district.

(3) Two new species of *Sigillaria* are described and figured.

(4) The known flora of the coalfield has been increased. Of the plants recorded—

6 species have not been recorded previously from Britain.
62 species have not been recorded previously from the coalfield, and
290 species have not been recorded previously from various localities in the coalfield.

Many of the species which have been previously recorded are here referred for the first time to definite horizons.

(5) The known vertical distribution of 38 species is extended to the Staffordian Series.

Note.—The general conclusions arising out of this work will be dealt with in the second part of this paper, which will be completed in June, 1925.

Botanical Department,
University of Bristol.

LITERATURE CITED.

Anstie, J. (1873), *The Coalfields of Gloucestershire and Somersetshire and their Resources*, 8vo, London.

Arber, E. A. N. (1904), "The Fossil Flora of the Culm Measures of North-West Devon": *Phil. Trans. Roy. Soc. Lond.*, ser. B, vol. cxcvii, pp. 291–325.

—— (1910), "On the Fossil Flora of the Southern Portion of the Yorkshire Coalfield in North Derbyshire and Nottinghamshire": *Proc. Yorks Geol. Soc.*, vol. xvii, pt. ii, pp. 132–55.

—— (1912), "On the Fossil Flora of the Forest of Dean Coalfield (Gloucestershire) and the relationships of the Coalfields of the West of England and South Wales": *Phil. Trans. Roy. Soc. Lond.*, ser. B, vol. ccii, pp. 233–81.

—— (1914 [1]), "On the Fossil Flora of the Kent Coalfield": *Q.J.G.S.*, vol. lxx, pp. 54–81.

—— (1914 [2]), "A Revision of the Seed Impressions of the British Coal Measures": *Annals of Botany*, vol. xxviii, No. cix, pp. 96–98–101.

—— (1914 [3]), "On the Fossil Floras of the Wyre Forest, with special reference to the Geology of the Coalfield and its relationships to the neighbouring Coal Measure Areas": *Phil. Trans. Roy. Soc. Lond.*, ser. B, vol. cciv, pp. 363–445.

—— (1916), "On the Fossil Floras of the Coal Measures of South Staffordshire": *Phil. Trans. Roy. Soc. Lond.*, ser. B, vol. ccviii, pp. 127–55.

—— (1920), "On the Fossil Flora of the Southern Portion of the Yorkshire Coalfield. Part II. Derbyshire": *Proc. Yorks Geol. Soc.*, vol. xix, pt. v, pp. 350–8.

—— (1922), "Critical Studies of Coal Measure Plant-impressions": *Journ. Linn. Soc.*, vol. xlvi, No. 307, pp. 178, 180, 186.

Brongniart, A. (1828–37), *Histoire des Végétaux Fossiles*, 2 vols., Paris.

Buckland, W., and Conybeare, W. D. (1824), "Observations on the South-Western Coal District of England": *Trans. Geol. Soc.*, ser. II, vol. i, p. 210.

Etheridge, R. (1868), "On the Physical Structure of the Northern Part of the Bristol Coal Basin": *Proc. Cottesw. Nat. Field Club*, vol. iv, p. 28.

Goode, R. H. (1913), "On the Fossil Flora of the Pembrokeshire Portion of the South Wales Coalfield": *Q.J.G.S.*, lxix, pp. 252–76.

Gothan, W. (1913), "Die Oberschlesische Steinkohlenflora": Teil I. Farne und farnähnliche Gewächse. (Cycadofilices bezw. Pteridospermen): *Abhandl. k. Preuss. Geol. Landesanst.*, N.F., Heft 75.

Greenwell, G. C., and M'Murtrie, J. (1864), *The Radstock Portion of the Somerset Coalfield*, 8vo, Newcastle-on-Tyne.

Kidston, R. (1885), "Notes on some Fossil Plants collected by Mr. R. Dunlop, Airdrie, from the Lanarkshire Coalfield": *Annals and Mag. of Nat. Hist.*, 1885, pp. 473–91.

—— (1886), *Catalogue of Palaeozoic Plants in the Department of Geology and Palaeontology, British Museum (Natural History), London*, 1886.

—— (1887), "On the Fossil Flora of the Radstock Series of the Somerset and Bristol Coalfield (Upper Coal Measures)": *Proc. Roy. Soc. Edinb.*, vol. xxxiii, pt. ii, pp. 335–417.

—— (1890), "The Yorkshire Carboniferous Flora": *Trans. Yorks. Nat. Union*, pt. xiv, pp. 3–64.

—— (1891), "On the Fructification of *Sphenophyllum trichomatosum* Stur, from the Yorkshire Coalfield": *Proc. Roy. Phys. Soc. Edinb.*, vol. xi, pp. 56–62.

—— (1893 [1]), "The Yorkshire Carboniferous Flora": *Trans. Yorks. Nat. Union*, pt. xviii, pp. 65–128.

—— (1893 [2]), "On the Fossil Plants of the Kilmarnock, Galston, and

Kilwinning Coalfields, Ayrshire" : *Trans. Roy. Soc. Edinb.*, vol. xxxvii, pt. ii, No. 16, pp. 307–58.

Kidston, R. (1893 [3]), "On Lepidopholios and the British species of the Genus" : *Trans. Roy. Soc. Edinb.*, vol. xxxvii, pt. iii, No. 25, pp. 529–63.

—— (1894 [1]), "On the Fossil Flora of the South Wales Coalfield" : *Trans. Roy. Soc. Edinb.*, xxxvii, pt. iii, No. 26, pp. 565–614.

—— (1894 [2]), "On the Various Divisions of the British Carboniferous Rocks as determined by their Fossil Flora" : *Proc. Roy. Phys. Soc.*, Session cxxiii, pp. 183–257.

—— (1901–2), "The Flora of the Carboniferous Period" : *Proc. Yorks Geol. and Polytech. Soc.*, vol. xiv, pt. ii (1901) ; pt. iii (1902).

—— (1903), "The Fossil Plants of the Carboniferous Rocks of Canonbie, Dumfriesshire, and of parts of Cumberland, and Northumberland" : *Trans. Roy. Soc. Edinb.*, vol. xl, pt. iv, No. 31, pp. 741–833.

—— (1905). "Divisions and Correlation of the Upper Portion of the Coal Measures" : *Q.J.G.S.*, vol. lxi, pp. 308–21.

—— (1911), "Les Végétaux Houillers recueillis dans le Hainaut Belge" : *Mém. Musee Roy. d. Hist. Nat. d. Belgique*, vol. iv.

—— (1913–14), In Cantrill and Pringle, *Summary of Progress of Geological Survey*, 1913, p. 101.

—— (1914), "On the Fossil Flora of the Staffordshire Coalfields" : Part III. The Fossil Flora of the Westphalian Series of the South Staffordshire Coalfield : *Trans. Roy. Soc. Edinb.*, vol. l, pt. i, No. 5, pp. 73–190.

—— (1916), "Contributions to our knowledge of British Palaeozoic Plants" : Part I. "Fossil Plants of the Scottish Coal Measures" : *Trans. Roy. Soc. Edinb.*, vol. li, pt. iii, No. 22, pp. 609–720.

—— Cantrill, T. C., and Dixon, E. E. L. (1917), "The Forest of Wyre and the Titterstone Clee Hill Coalfields" : *Trans. Roy. Soc. Edinb.*, vol. li, pt. iv. No. 27.

—— (and Jongmans, W. J. (1917)), "Monograph of the Calamites of Western Europe" : Flora of the Carboniferous of the Netherlands and adjacent regions, vol. i. *Mems. of the Government Institute for the Geological Exploration of the Netherlands.*

—— (1919), "List of the Fossil Plants from the Coal Measures of the Borings at Bere Farm, Elham, Folkestone, and Lydden Valley, Kent" : in *Summary of Progress of Geol. Survey. for* 1918, pp. 46–9.

—— (1923), "Fossil Plants of the Carboniferous Rocks of Great Britain" : *Mems. of Geol. Survey of Gt. Britain*, vol. ii, pts. i–iv.

Lesquereux, L. (1884), *Description of the Coal Flora of the Carboniferous Formation in Pennsylvania*, vol. iii.

Lillie, D. G. (1910), "Notes on the Fossil Flora of the Bristol Coalfield" : Geol. Mag., pp. 58–67.

Lindley, J., and Hutton, W. (1831–7), *The Fossil Flora of Great Britain*, London, vols. i–iii.

M'Murtrie, J. (1875), "Notes on the Physical Geology of the Carboniferous Strata of Somersetshire and associated formations" : *Somerset Archaeological and Nat. Hist. Soc.*, 1875, pp. 41–52.

—— (1900), "The Geological Features of the Somerset and Bristol Coalfield" : Read at the Annual General Meeting of the Institution of Mining Engineers, 1900.

Potonié, H. (1903–13), "Abbildungen und Beschreibungen fossiler Pflanzenreste der palaeozoischen und mesozoischen Formationen" : *K. Preuss. Geol. Landesanst.*, Berlin.

Renier, A. (1910), *Documents pour L'Étude de la Paléontologie du Terrain Houiller*, Liège, 1910.

Stoddart, W. W. (1875–6), "On the Geology of the Bristol Coalfields" : *Proc. Bristol Nat. Soc.*, N.S., vol. i, pp. 341 and 350.

Schimper, W. Ph. (1869–74), *Traité de Paléontologie Végétale*, vols. i–iii, Paris, 1869–74.

Scott, D. H., and Maslen, A. J. (1907), "The Structure of the Palaeozoic Seeds, *Trigonocarpus parkinsoni* Bgt. and *Trigonocarpus oliveri* sp.nov. Part I.": *Annals of Botany*, vol. xxi, p. 89.

Vernon, R. D. (1912), "On the Geology and Palaeontology of the Warwickshire Coalfield": *Q.J.G.S.*, vol. lxviii, p. 587.

Wethered, E. (1878), "The Carboniferous Flora of the Bristol Coalfield": *Proc. Cotteswold Nat. Field Club*, vol. vii.

Watts, W. W. (1922), "Carboniferous Nomenclature": GEOL. MAG., Vol. LIX, P. 238.

White, D. (1899), "Fossil Flora of the Lower Coal Measures of Missouri". *Monographs of the U.S. Geol. Surv.*, vol. xxxvii.

Zeiller, R. (1886–8), *Flore Fossile du Bassin Houiller de Valenciennes*, Paris, 1888.

—— (1890), "Bassin Houiller et Permien d'Autun et d'Épinac. Fasc. II, Flore Fossile": *Études des Gîtes Minéraux de la France*, Paris, 1890.

—— (1906), "Bassin Houiller et Permien de Blanzy et du Creusot. Fasc. II, Flore Fossile": *Études des Gîtes Minéraux de la France*, Paris, 1906.

EXPLANATION OF PLATES VI–IX.

PLATE VI.

FIG.

1.—*Sigillaria kidstoni* n.sp., from Broad Oak Colliery, Pensford. × $\frac{2}{3}$.

2.—*Renaultia chaerophylloides* Brongt. sp., from Broad Oak Colliery, Pensford. × 1.

3.—*Sphenopteris laurenti* Andrae, from Bromley Colliery. No. 5 Seam. × 1.

4 and 5.—*Holcospermum mamillatum* Lesqx. sp., from Broad Oak Colliery, Pensford. × 1.

PLATE VII.

1.—*Sigillaria nortonensis* n.sp., from Norton Hill Pit, near Midsomer Norton. × $\frac{2}{3}$.

2.—*Neuropteris pseudogigantea* Potonié, from Deep Pit, Kingswood, Bristol. × $\frac{2}{3}$.

3.—*Pecopteris crenulata* Brongt., from Bromley Colliery. No. 5 Seam. × $\frac{1}{3}$.

4.—*Lepidodendron obovatum* Sternb., from Deep Pit, Kingswood, Bristol. × 1.

PLATE VIII.

1.—*Sigillaria* cf. *germanica* Weiss, from Broad Oak Colliery, Pensford. × 1.

2.—*Sigillaria ovata* Sauveur, from Broad Oak Colliery. Pensford. × $\frac{2}{3}$.

3.—*Sigillaria deutschiana* Brongt., from Parkfield Colliery, near Pucklechurch. × $\frac{2}{3}$.

4.—*Pecopteris volkmanni* Sauveur, from Deep Pit, Kingswood, Bristol. × 1.

PLATE IX.

1.—*Sigillaria transversalis* var. *sparsifolia* Boulay, from Broad Oak Colliery, Pensford. × 1.

2.—*Sphenopteris* (*Corynepteris*) *sternbergi* Ett. sp., from Broad Oak Colliery, Pensford. × 1.

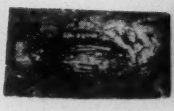
3.—*Sigillaria mauricii* Grand 'Eury, from Broad Oak Colliery, Pensford. × 1.

4.—*Lepidodendron distans* Lesqx., from Broad Oak Colliery, Pensford. × 1.

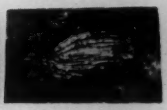
1. × 9/7

3. ×1

2. ×1



4. ×1

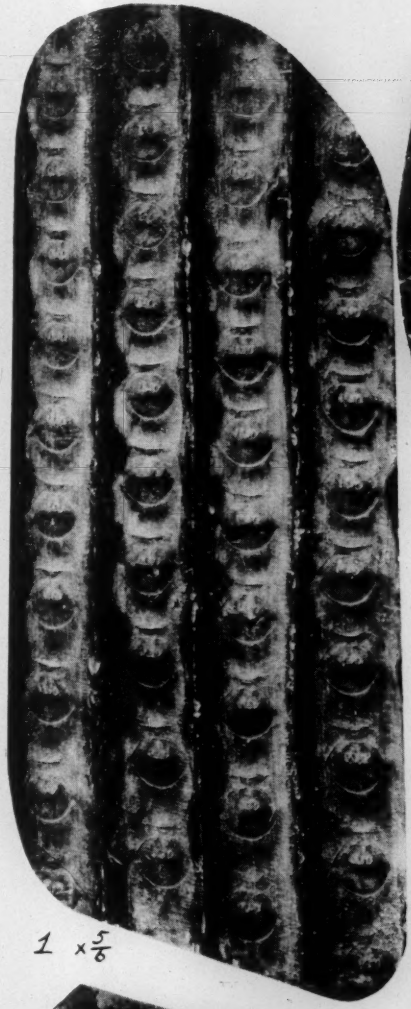


5. ×1

R. Crookall, Photo.

FOSSIL PLANTS FROM THE BRISTOL AND SOMERSET COALFIELD.

[*To face p. 180.*



1 $\times \frac{5}{6}$

2. $\times \frac{3}{4}$

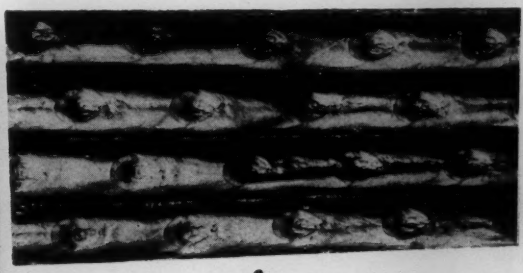
3. $\times \frac{4}{3}$

4. $\times 1$

R. Crookall, Photo.

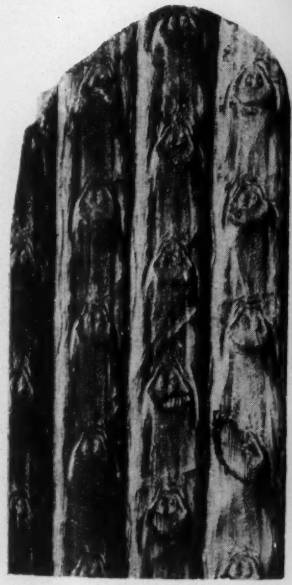
FOSSIL PLANTS FROM THE BRISTOL AND SOMERSET COALFIELD.

1. × 1



2. × ⅔

4. × 1



3. × ⅔

R. Crookall, Photo.

FOSSIL PLANTS FROM THE BRISTOL AND SOMERSET COALFIELD.

1. ×1

2. ×1

3. ×1

4. ×1

R. Crookall, Photo.

FOSSIL PLANTS FROM THE BRISTOL AND SOMERSET COALFIELD.

Faunal Horizons in the Lower Carboniferous of North-West Yorkshire.

By R. G. S. Hudson, M.Sc., F.G.S.

RECENT papers and discussions have called attention to the fauna of the Yoredale facies of the Lower Carboniferous. These beds are well exposed in the valleys of Wensleydale and Swaledale in North West Yorkshire and they are there, perhaps, the most fossiliferous. As this is the type district for the Yoredale series, a brief statement of the more important faunal horizons would not be out of place.

The Yoredale series consists of shales, sandstones, and limestones, but only to the beds of limestone were distinctive names given. (Phillips, 10, p. 37.)[1] In this paper the name of the limestone is also used to distinguish the underlying shale and sandstone. The lithological succession has been described in a recent paper (7), which includes diagrams showing the succession of the beds. It is also noted in the same paper how the different conditions of sedimentation resulted in a great variation in the types of faunal assemblages, but in spite of this, the fauna of the various beds is sufficiently definite to allow of the establishment of faunal horizons and correlation with other areas.

The Yoredale series is all referable to the D zone of the Lower Carboniferous, but division in terms of D_2 and D_3 has not been attempted.

The use of D_3 in Lower Carboniferous zonal nomenclature has caused much confusion and makes the use of that symbol for the horizons above D_2 inadvisable (4, pp. 14–17), although such horizons do undoubtedly occur in the "Yoredales". Originally used as a term denoting a faunal horizon immediately above D_2 (11, pp. 50–3), the fauna indicated by D_3 is now recognized as a phasal fauna of "Zaphrentid phase" type, equivalent to various horizons in the *Dibunophyllum* zone (3, pp. 72–3). Such a fauna is found in the Yoredale series in the Gayle Shale below beds of undoubted D_2 age.

The symbol Dy is more intimately bound up with the question of Yoredale faunas as it is often used as synonymous with the term "Yoredalian", a time-name first used by Mr. Cosmo Johns to express the horizon of the Yoredale series, which he considered to be all above D_2 (8). Dy was first used by Dr. Vaughan (13) as a phasal equivalent of D_3 (the Zaphrentid-Cyathaxonia phase) or P (the goniatite-lamellibranch phase). It denoted a standard limestone fauna, "the continuation and apotheosis of the earlier D_2 fauna," and was used by him as a zonal phasal horizon for the Yoredale series. The use of the one term to express both a zonal and a phasal meaning leads to much confusion, and the use of Dy was

[1] Figures in parentheses refer to bibliography at end of paper.

the more unfortunate as both the Dy phase (normal limestone fauna) and the D_3 phase (Zaphrentid-Cyathaxonia fauna) are equally well represented in the "Yoredales", which, moreover, contain representatives of the P phase (goniatite-lamellibranch fauna). In addition the D_2 of North-West Yorkshire has a true Dy phase, for the Yoredale conditions of deposition extend down to the base of D_2 where the *Girvanella* bed, which marks the junction between D_1, and D_2 initiates the shale, sandstone, and limestone type of sedimentation. The recent use of Dy as a purely zonal horizon immediately above D_2 is contrary to the original idea of Dr. Vaughan, and since it is regarded by many as synonymous with "Yoredalian", has little precise meaning.

Faunal Horizons.

D_1.—About 30 feet of limestone are exposed in Wensleydale below the *Girvanella* bed. These beds form a large inlier in the bottom of the valley and extend up several tributary valleys. The fauna is of the usual D_1 type. Reefs of *Lithostrotion junceum*, *L. irregulare*, *L. martini*, *Diphyphyllum* cf. *lateseptatum*, and *Syringopora* spp. are common, while *Productus maximus* is the characteristic brachiopod. Nowhere in the district under consideration is the *Cyrtina septosa* band met with.

D_2.—The faunal assemblages of the lower limestones of the "Yoredales" agrees that with of D_2 of other districts. This fauna is found not only in the Great Scar Limestone from the *Girvanella* bed upwards, but also in the next series of beds above, namely, the Gayle Shale and the Gayle Limestone. The former contains a Zaphrentid phasal fauna (modified limestone phase of the author (1)). The Gayle Limestone contains the *Productus* cf. *giganteus* band (lower *Lonsdaleia* beds) of the Ingleborough district and N.W. Province (5, p. 494). These beds, here as elsewhere, contain *Productus* cf. *giganteus* and *P. sulcatus* in abundance. In some sections a further fossiliferous horizon is found above the *P.* cf. *giganteus* band. This contains *Pustula punctata*, which is very common, associated with *Productus pinguis* Muir-Wood (MS.), *P. sulcatus* and *P. antiquatus*. This fauna is almost entirely a brachiopod one and is probably consequent on a particular sedimentation. Two thin posts of limestone in D_2 contain *Saccammina carteri* almost to the exclusion of any other fossil. The lower band occurs in the first thin limestone immediately below the Gayle Shale while the upper band is found about 15 feet above the *P.* cf. *giganteus* band. These beds bear no relation in horizon to the *Saccammina* beds (Spotted Post) of Northumberland. Those beds are the equivalent in the Yoredales of the horizon of the Middle Limestone or the beds above.

Hardraw Limestone Series.—The next group of associated beds is that of the Hardraw Shale, Sandstone, and Limestone.

The Hardraw Shales, which rest on the Gayle Limestone with

a local unconformity, are, as a whole, unfossiliferous with the exception of the 3 feet at the base which contains numerous fossils and forms an important faunal horizon for purposes of correlation. The base of the shale contains a crowded layer of concretionary nodules which show, in thin section, the "bean"-shaped organisms referred to by Professor E. J. Garwood (6, p. 203). Immediately above this the shale contains, amongst other fossils, *Productus tissingtonensis* and *Posidonomya becheri*. Both of these are of zonal importance. The former was first described by Professor T. F. Sibly, from Derbyshire, where he regarded it as characteristic of the "D_3" zone (11, p. 77). In the Yoredales it attains its maximum at the base of the Hardraw Shales. The importance of *P. becheri* is emphasized by its association with goniatites. At this horizon the goniatites are fragmental, but about 12 feet higher, the goniatite-lamellibranch fauna reappears with *P. becheri* and *Goniatites crenistria* as characteristic fossils. The same fauna is found in the Pendleside Series where it occurs at the top of the Pendleside Limestone and the base of the overlying shales. This suggests that the original correlation by Tiddeman of the Pendleside Limestone with the top of the Great Scar Limestone is correct. First suggested in the Memoir of the Burnley Coalfield, and amplified in later papers, the correlation has in late years been questioned. Dr. Vaughan, Professor Garwood, and Mr. Cosmo Johns have all adopted that of Professor Marr, in which he correlates the Pendleside Limestone with the Main Limestone of the Yoredales, a correlation not borne out by any similarity in the fauna.

The Hardraw Limestone contains a normal limestone fauna of which the following are the most characteristic :—

Alveolites sp.
Cyathophyllum murchisoni var. cf. *stutchburyi* Edw. & Haime.
Lonsdaleia floriformis crassiconus McCoy.
Productus cf. α, S. Smith.

In certain sections in the Hardraw Limestone the beds are seen to be crowded with Productids, chiefly *Productus hemisphericus*. *Productus pugilis* and *Productus* sp. nov. also occur, and the former enables correlation to be made with the *P. pugilis* beds of the Ingleborough district (6, p. 205). A similar bed is recorded in the Lower Carboniferous rocks of Durham (7, p. 147), and apparently the horizon is approximately the same.

Simonstone Limestone Series.—Neither the limestone nor the shales of the Simonstone series are very fossiliferous and still less are fossils characteristic of this horizon at all common. *Cyathophyllum regium* and *Productus edelburgensis* are locally characteristic of the Simonstone Limestone. The holotype of the latter may have been obtained from this horizon as Phillips records it as from the "middle of Yoredale limestones, Addelburgh", Wensleydale. The most important fauna, however, in the Simonstone is found

in the top 6 feet of the limestone. It contains *Orionastrea* sp. nov., which is confined to this horizon and forms an important faunal band which has been traced over a wide area in N.W. Yorkshire, including Teesdale, Swaledale, Wensleydale, and Wharfedale. It also occurs in the Ingleborough district, where its horizon has not been differentiated from that of *Orionastrea phillipsi*, which in North West Yorkshire occurs at the base of the Middle Limestone. *Orionastrea* sp. nov. is distinguished from *O. phillipsi* by its very irregular dissepiments and lack of septa.

The correspondence of the faunal horizons of the Yoredale district and the Ingleborough district enables an interesting lithological comparison to be made. The following tables compare the thickness of the various beds between the *Girvanella* band and the *Orionastrea* band at Askrigg, Wensleydale, and at Fairweather Springs, Ingleborough (6, p. 204). The sections are about 11 miles apart, and it is interesting to note the lithological change in that short distance. The grits of the one section are not represented in the other, while the rapid thinning of the shales foretells their dying out southward. The limestones, too, are decreasing in thickness, but the Craven faults prevent any further knowledge of their ultimate reduction.

Askrigg, Wensleydale.	Feet.		Fairweather Springs, Ingleborough.	Feet.	
Orionastrea band.			*Orionastrea* band.		
Simonstone Limestone with *Productus edelburgensis* and *P. latissimus* . .		30	Limestone with *P. latissimus* . . .		12
Grit with occasional shales and limestone . .	75				
Shale	6		Shales		12
	—	81			
Hardraw Limestone—					
Limestone . . .	28		Limestone . . .	8	
Shale	1		Limestone (Lamellibranch bed)	5	
Limestone . . .	37		Limestone . . .	16	
	—	66		—	29
Grit	24				
Shale	54		Shales with *Aulophyllum* .		12
	—	78			
			Not seen		10
Lower *Lonsdaleia* beds—					
Gayle Limestone . .	33				
Gayle Shale . . .	18		Lower *Lonsdaleia* beds .		30
Great Scar Limestone .	49				
	—	100			
Girvanella band.			*Girvanella* band.		
Total . . .		355	Total . . .		105

Middle Limestone Series.—The Middle Limestone of Wensleydale consists of three limestones separated by thin shales. They are equivalent to the Single Post, Cockleshell, and Scar Limestones

of Teesdale, and are there separated by considerable thicknesses of sandstone and shale.

An important zonal fauna occurs at the base of the lowest limestone, the Single Post. The chief elements in the fauna are :—

Alveolites sp.
Lithostrotion sp. nov., cf. *L. portlocki* (Bronn).
Orionastrea phillipsi (McCoy).

This fauna is a very constant feature at the base of the Middle Limestone in North-West Yorkshire, and corresponds to part of the *Orionastrea* band of the Ingleborough district (6, pp. 205–7).

The next limestone above, the Cockleshell Limestone, was so called because of the occurrence of *Productus giganteus* Martin and various related species. This form is almost confined to the limestone and the shale immediately above it, and it is quite distinct from the *P.* sp. (*giganteus* group) of the Gayle Limestone and also from that of the Main Limestone. Occasional specimens of the Productus are found in the Scar Limestone, the fauna of which contains no distinguishing element. On the other hand, the 3 feet of shale immediately above the Scar Limestone has a fauna which has been of great assistance in correlating the various exposures from Teesdale to Wharfedale. The fauna, which is a Zaphrentid phasal one, contains the following important forms :—

Cyathaxonia cornu Mich.
Zaphrentis cf. *ambigua* mut. σ Vaughan.
Zaphrentis constricta Carruthers.
Zaphrentis cf. *constricta* (Densiphylloid variant).
Zaphrentis eruca and variants (McCoy) abundant.
Zaphrentis sp., cf. *Densiphyllum costatum* S. Smith (12, Pl. I, Fig. 11).
Zaphrentis oystermouthensis Vaughan.

The above fauna may be found to have a wider use in the correlation of more distant areas, for similar faunas have been recorded from the Westmorland Pennines (5, p. 540), Northumberland (2, pp. 83–4 ; 12, pp. 615–17), and Dunbar, Scotland (1, pp. 71–2), from beds which are probably similar in horizon.

The fauna of the beds between the Middle Limestone and the Undersett has no distinctive feature with the exception of that found in the Five Yards Limestone which is often locally crowded with *Productus* cf. *auritus*.

Undersett and Main Limestone Series.—The fauna of the Undersett is also not a very distinctive one, but corresponds with that of the Main Limestone above rather than with the beds below.

Fossiliferous bands chiefly containing Dibunophyllids, including several variants of *Dibunophyllum muirheadi*, occur in both limestones. The fauna, however, which is distinctive of the Main Limestone, is the normal coral-brachiopod one. The corals are chiefly members of the *Lonsdaleia* gens, the chief forms found being :—

Lonsdaleia caledonia S. Smith.
Lonsdaleia cf. *laticlavia* S. Smith.
Lonsdaleia sp. nov. (end form of a *Lonsdaleia* gens).
Thysanophyllum orientale Thomson.

The brachiopods are various giganteid Productids which seem to be the katagenetic forms of several species of *Productus*. The fauna is most abundant in a fossiliferous band towards the top of the Main Limestone, but occasional individuals do occur sporadically throughout the limestone.

Two of the above species (*L. caledonia* and *T. orientale*) have previously only been recorded from Scotland—a fact which bears out the inference formed from a general survey of the fauna of the Yoredales, namely, that it is much more closely connected with the fauna of the Lower Carboniferous of the North of England and Scotland. Such a similarity is probably due in part to equivalent conditions of deposition but it also points to the probability that the upper Yoredale beds are of a higher horizon than the Lower Carboniferous beds to the south.

BIBLIOGRAPHY.

Only those papers are noted which have been referred to in the text.

1. R. G. Carruthers, "Summary of Progress," for 1921: *Mem. Geol. Surv.*, 1922.
2. —— "Summary of Progress," for 1923: *Mem. Geol. Surv.*, 1924.
3. E. E. L. Dixon, "The Country around Pembroke and Tenby": *Mem. Geol. Surv.*, 1921.
4. —— "A Sketch of the Geology of the Whitehaven District": Advance Expedition Pamphlet: *Geol. Assoc. London*, July, 1924.
5. E. J. Garwood, "The Lower Carboniferous Succession in the North-West of England": *Q.J.G.S.*, vol. lxviii, 1912.
6. —— and Miss E. Goodyear, "The Lower Carboniferous Succession in the Settle District": *Q.J.G.S.*, vol. lxxx, 1924.
7. R. G. Hudson, "The Rhythmic Succession of the Yoredale Series in Wensleydale": *Proc. York. Geol. Soc.*, vol. xx, pt. i, 1923–4.
8. Cosmo Johns, "On the Classification of the Lower Carboniferous Rocks": Geol. Mag., 1910.
9. G. W. Lee, Appendix 1 "Summary of Progress" for 1923: *Mem. Geol. Surv.*, 1924.
10. J. Phillips, "Illustrations of the Geology of Yorkshire," Part 2: *The Mountain Limestone District*, London, 1836.
11. T. F. Sibley, "The Faunal Succession in the Carboniferous Limestone of the Midland Area": *Q.J.G.S.*, vol. lxiv, 1908.
12. Stanley Smith, "The Faunal Succession of the Upper Bernician": *Trans. Nat. Hist. Soc. Northumberland and Durham*, N.S., vol. iii, 1908–11.
13. A. Vaughan, "Faunal Succession in the Lower Carboniferous Limestone (Avonian) of the British Isles": *Rep. Brit. Assoc. for* 1909 (Winnipeg), 1910.

Note on the Age of the Rocks around the Teifi Estuary.

By M. P. Latter, B.A., F.G.S.

IN the course of detailed mapping over this area, with a view to throwing some light on the complicated geological structure of the district, the discovery of various graptolites, largely from new localities, both confirms and extends the previous records of Dr. C. A. Matley [1] and Mr. W. Keeping.[2]

The rocks of this area fall within two distinct groups—a lower group of dark shales and grits, and an upper group of cleaved pale-coloured shales and mudstones. Some horizons, however, in the Lower Group, are not so very dissimilar in colour and appearance from the Upper more uniform series, and the fact that nearly all the rocks in the district exhibit cleavage to some degree (though this is usually more pronounced in the Upper Group, as there are no definite grit bands here to arrest it) adds to the difficulty of differentiating between the two groups.

The extensive series of grey shales and mudstones of the Upper Group, which stretch away east and north-east of the Teifi Estuary towards Aberporth, appear to be quite unfossiliferous, or, at any rate, in the lower horizons (Professor O. T. Jones [3] records certain graptolitic beds near Newcastle Emlyn, which may be high up in this group). It is therefore necessary to turn to the Lower Group, which underlies these rocks conformably, for evidence of their age.

The writer is gratefully indebted to Dr. G. L. Elles for examining the greater number of the graptolites, and identifying them where it has been possible: the following extracts from her report are given below:—

"Specimens for the most part very poorly preserved, and much cleaved and sheared. In this condition it is practically impossible to be certain of the separation of *Orthograptus acutus* from *Orthograptus vulgatus*, though there is some suggestion that the more abundant species represented is *Orthograptus vulgatus*, with which is associated also in some abundance *Orthograptus intermedius*. . . . I fancy two definite horizons are represented:—

(*a*) Lower. *Mesograptus multidens.*
(*b*) Upper. *Orthograptus vulgatus, O. intermedius*, etc."

The following graptolites have been obtained from the undermentioned localities:—

(*a*) Cliff-top, ½ Mile S.W. of Ceibwr Bay.
Mesograptus multidens Elles and Wood.
Cryptograptus (*tricornis* ?) Carruthers.
Climacograptus sp.

[1] "On the Geology of part of North-East Pembrokeshire": *Birm. Nat. Hist. and Phil. Soc.*, 1896.
[2] "The Geology of Cardigan Town"; Geol. Mag., 1882, p. 521.
[3] *Q.J.G.S.*, vol. lxviii, 1912, p. 334.

(*b*) Second Quarry S.E. from Moylgrove.
Orthograptus acutus or *vulgatus* Lapworth.
(*c*) 600 Yards E. of Pant Saeson, Monington.
Climacograptus Scharenbergi Lapworth.
Climacograptus sp.
(*d*) South Bank of Teifi, ¼ mile E. of St. Dogmells.
Orthograptus (*acutus* ?) Lapworth.
Orthograptus (*vulgatus* ?) Lapworth.
Climacograpus (*Scharenbergi* ?) Lapworth.
Orthograptus truncatus, var. *intermedius* Elles and Wood.
(*e*) North Bank of Teifi, Netpool.
Orthograptus acutus Lapworth.
Orthograptus vulgatus Lapworth.
Orthograptus truncatus, var. *intermedius* Elles and Wood.
Cryptograptus (*tricornis* ?) Carruthers.
Climacograptus Scharenbergi Lapworth.
(*f*) Shore, S.E. of Pen-y-bal, Newport Bay.
Cryptograptus tricornis Carruthers.
Orthograptus trumcatus, var. *intermedius* Elles and Wood.
(*g*) Disused Silver-lead Mines, Llanfyrnach.
Orthograptus truncatus, var. *intermedius* Elles and Wood.

From the above list of graptolites little indication is given of the exact horizons of these localities, but the presence of *Mesograptus multidens* associated with *Cryptograptus* (*tricornis* ?) in shales near Ceibwr Bay suggests a lower horizon for these beds than for the shales round St. Dogmells and Cardigan, while the beds of Newport further west, as shown both by the fossils of Dr. Matley, and the somewhat negative evidence yielded here by *Cryptograptus tricornis*, appear older than the Cardigan beds. The late Professor Lapworth identified the graptolites found by Mr. W. Keeping S.W. of Cardigan Town (op. cit.) as *Dicellograptus morrisii* (Hopk.) and *Diplograptus socialis* (Lapw.), and these definitely indicate the topmost zones of the *Dicranograptus* shales, either the zone of *Dicranograptus clingani* or that of *Pleurograptus linearis*.

Thus, although a gradual rise in sequence is probable as the beds are traced north-eastwards from Newport to Cardigan this lower group of dark shales and grits forms only a *part* of the *Dicranograptus* shales, and may represent in itself a more arenaceous facies of contemporaneous shales elsewhere.

At a future date it is hoped it will be found possible to give an account of the geological structure of these rock groups, when the age of the beds can be more fully discussed.

REVIEWS.

DIE GRUNDLAGEN DER ALPINEN TEKTONIK. By F. HERITSCH. pp. 259, with 33 text-figures. Berlin: Gebrüder Borntraeger, 1923.

DIE ALPINE FALTUNG. By H. JENNY. pp. viii + 176, with 3 plates and 25 text-figures. Berlin: Gebrüder Borntraeger, 1924.

AMONGST Alpine geologists there are two distinct schools of thought, which for convenience may be called the West Alpine and East Alpine schools. The ideas of the former originated in the Western Alps and of the latter in the Eastern Alps, but they are no longer strictly regional in their distribution. Almost all West Alpine geologists belong to the West Alpine school, but though the majority of the workers in the Eastern Alps belong to the other there are several who hold West Alpine views. The West Alpine school is thus the dominant one in the Alps, but isostasists favour the East Alpine school, because it offers the only prospect of reconciling their theories with the facts of Alpine structure.

Heritsch belongs to the East Alpine school and Jenny to the West Alpine. Neither of their books is written for those who know nothing of the Alps. Heritsch is the more exacting in his demands. He supposes that the reader is acquainted with the geology of the Alps and is familiar with the Decken or Nappe theory, and his book is a discussion rather than a description of Alpine structure. Jenny assumes the correctness of the West Alpine view, and on this basis describes the structure. Consequently his book is the easier to read.

Heritsch does not believe in the gigantic recumbent folds with their supposed roots which are postulated by West Alpine geologists, nor does he think that the strata of the northern limestone Alps were originally deposited far to the south of the present axis of the range. Decken indeed there are, but they are not recumbent folds. There has been great compression and the beds are closely packed, sometimes by intense folding, sometimes by minor thrusts. In some areas the closely packed mass has been separated from its basis by a major thrust. But the actual displacements have been small compared with those imagined by the West Alpine school. He recognizes that the Eastern Alps are a distinct unit and that along their junction with the Western Alps there has been overthrusting towards the west, but only to a limited extent. Essentially the two grew up side by side. In general the horizontal movements that he requires are much more modest than those demanded by the West Alpine school, and he attributes more effect to vertical or steeply inclined displacements. His structures are more like those of the North-West Highlands than the recumbent folds of Swiss and French geologists.

With regard to the origin of mountain ranges Heritsch rejects

the contraction theory and adopts the Verschluckungs hypothesis of Ampferer. "Verschluckung" may be translated as "swallowing" or "gulping down". Ampferer supposes that the outer crust of the earth is passive and beneath it lies an active layer in which earth-movements originate. The processes of mountain-building begin in a Verschluckungs-zone, lying approximately along the axis of the future mountain range. In this zone some of the material of the active layer sinks downwards and consequently the two sides of the zone approach each other, drawing with them the points of the passive layer immediately above them. The passive layer sags downwards and, being too wide a covering for the narrowing zone, it fractures and the pieces are thrust over one another and piled up, forming the mountain mass. Obviously such a theory involves a number of other consequences. Unless there are cavities in the earth's interior or its volume alters, the sinking of material in the Verschluckungs-zone must be accompanied by an equivalent rising elsewhere. A complete system of currents must exist in the active layer, and there is no evidence either for or against such a system. Moreover, if the passive layer fits the interior and any part of it is pinched up, there must be stretching in other areas, unless the interior contracts. Heritsch mentions with approval an exposition of the Verschluckungs-hypothesis by Schwinner. Schwinner compares the passive layer with the stratosphere of meteorologists and the active layer with the troposphere. In the active layer convection produces rising and falling currents and connecting horizontal currents. The Verschluckungs-zone is a zone of falling currents. It is curious that while meteorologists are finding convection in the active layer inadequate to explain the disturbances in that layer and are seeking for causes either at its junction with the passive layer or in the passive layer itself, isostasists are looking to convection in the active layer as the cause of the disturbances in both.

Jenny's book need not detain us so long. The view that he takes of the general structure of the Alps is now the orthodox one and is widely known. Less than 30 years ago it was heterodox; but with a fine open-mindedness its most illustrious opponents among the older geologists, Heim in Switzerland and Termier in France, in a few years became convinced of its truth and are now to be numbered with its warmest supporters. Within the limits of orthodoxy, however, there is still room for differences of opinion, especially with regard to such questions as the relation of the Dinaric Alps to the main range, and Jenny's interpretation is very different from that of Kober.

About half, and in his own opinion the more important half, of Jenny's volume is devoted to the consideration of the dates at which the various movements took place, and here he is distinctly heterodox. It is usually thought that all the intense folding of the Alps is of Tertiary age. According to Jenny some of the

recumbent folds belong to a much earlier period. In the Pennine system, for example, some of them were formed in Middle Jurassic times.

In a short notice it is not possible to do justice to either the West Alpine or the East Alpine point of view. The impartial reader of the works of both schools will be forced to the conclusion that however great our knowledge of parts of the Alps may be, we know little about the structure of the range as a whole, and nothing about the causes that produced the structure. He may well doubt the generalized sections of the one school, which consist chiefly of lines drawn in the air, and those of the other, which require an equal amount of imagination underground. But he should not conclude that either interpretation is useless.

P. L.

A History of British Earthquakes. By Charles Davison, Sc.D., F.G.S. pp. xviii + 416. Cambridge University Press, 1924. 25*s.* net.

THIS work is essentially one of those which Lamb classed as books that are not books: no one could sit down to read it steadily through, yet it is nevertheless one which, had it not been published, would have been a loss to those who are interested in earthquakes, in the old-fashioned meaning of the word. For years past Dr. Davison has not allowed us to forget that there are earthquakes in Britain, yet it came as somewhat of a surprise to the reviewer to find the amount and variety of information regarding the different effects, and manifestations, of earthquake action, which could be illustrated, or even amplified, by observations within our little island. The evidence of what are called vorticose shocks, in the rotation without overthrow of objects, is recorded in two instances, and one of these, the London earthquake of 1750, holds priority of record, until someone, delving in the pages of old volumes, finds an earlier account. There are some interesting records of the comparative sensitiveness of different animals to vibrations set up by the earthquake: in the Hereford shock of 1896 it was recorded that cats noticed the shock to a distance of 22, cattle to 34, horses to 83, and dogs to 109 miles some; birds were distinctly more sensitive, and pheasants were set crowing at 145 miles from the centre. One feature of the British earthquakes, which had not been unnoticed before, comes out with prominence when the records are all collected together, and that is the great size of the disturbed area; as compared with a typical earthquake country like Italy, the dimensions of the area over which the disturbance can be felt run to quite double, on the average, in the British earthquakes, for shocks which attain the same degree of intensity at the epicentre. A good index is essential to a volume of this kind, and the index in this one is unusually full and detailed.

R. D. O.